

SUMMARY OF RESEARCH 1998

Interdisciplinary Academic Groups

C3 - Dan Boger, Chair

Information Systems - Dan Boger, Chair

Information Warfare - James Powell, Chair

Space Systems - Rudolf Panholzer, Chair

Undersea Warfare - James Eagle, Chair

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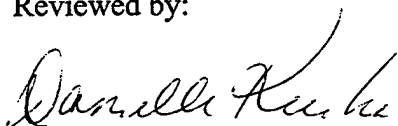
Rear Admiral R.C. Chaplain, USN
Superintendent

R. Elster
Provost

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Reviewed by:



Danielle A. Kuska
Director, Research Administration

Released by:



David W. Netzer
Associate Provost and Dean of Research

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13. ABSTRACT (Maximum 200 words)

This report contains information of research projects in the interdisciplinary groups, Command, Control, and Communications Academic Group, Information Systems Academic Group, Information Warfare Academic Group, Space Systems Academic Group, and Undersea Warfare Academic Group. A list of recent publications is also included which consists of conference presentations and publications, books, contributions to books, published journal papers, technical reports, and thesis abstracts.

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Information Systems

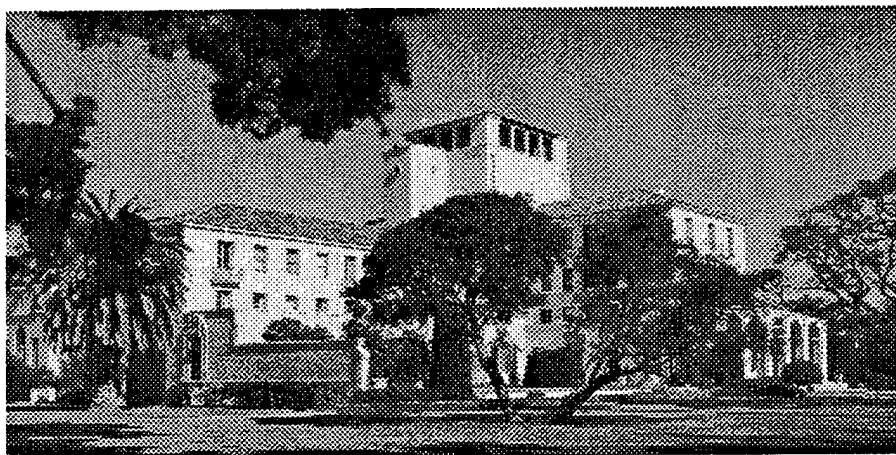
Information Warfare

Space Systems

Undersea Warfare

THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the USA through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges.



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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the School's eleven academic departments, seven interdisciplinary groups, and the School of Aviation Safety. This volume contains research summaries for the projects undertaken by faculty in the Academic Groups (Command, Control, and Communications, Information Systems, Information Warfare, Space Systems, and Undersea Warfare) during 1998. Two new interdisciplinary groups were formed in 1999, Special Operations and Modeling, Virtual Environments, and Simulation. Also included is an overview of each academic group, faculty listings, compilations of publications/presentations, and abstracts from theses directed by the academic groups faculty.

Questions about particular projects may be directed to the faculty Principal Investigator listed or the Academic Group Chair. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the NPS Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil~code09/>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing militarily relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, permitting them to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. This capability is especially important at the present time when technology in general, and information operations in particular, are changing rapidly. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focussed graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at NPS consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with other government laboratories and universities, provides off-campus courses either on-site at the recipient command or by VTC, and provides short courses for technology updates.
- **NPS Institutionally Funded Research Program (NIFR):** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursable sponsored, (4) to contribute to the recapitalization of major scientific equipment, and (5) to cost-share the support of a strong post-doctoral program.
- **Institute for Joint Warfare Analysis (IJWA) Program:** The IJWA Program provides funding to stimulate innovative research ideas with a strong emphasis on joint, interdisciplinary areas. This funding ensures that joint relevance is a consideration of research faculty.

In 1998, the overall level of research effort at NPS was 145 faculty workyears and exceeded \$35 million. The Academic Groups' effort was 8.15 faculty workyears and exceeded \$3 million. The sponsored research program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY98 over 81% percent of the NPS research program was externally supported. In the Academic Groups 92% was externally supported.

Research sponsorship in FY98 for the Command, Control, and Communications Academic Group is provided in Figure 1, Information Warfare Academic Group in Figure 2, Space Systems Academic Group in Figure 3, and Undersea Warfare Academic Group in Figure 4. A profile for Information Systems Academic Group is not provided as the group was transitioning during FY98.

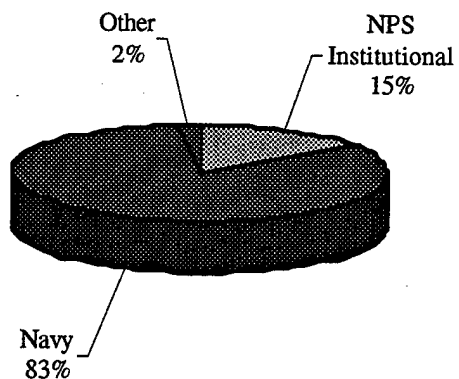


Figure 1. FY98 Sponsor Profile of the Command, Control, and Communications Academic Group

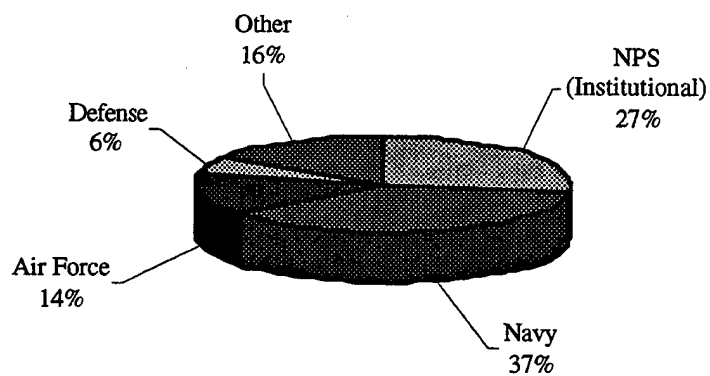


Figure 2. FY98 Sponsor Profile of the Information Warfare Academic Group

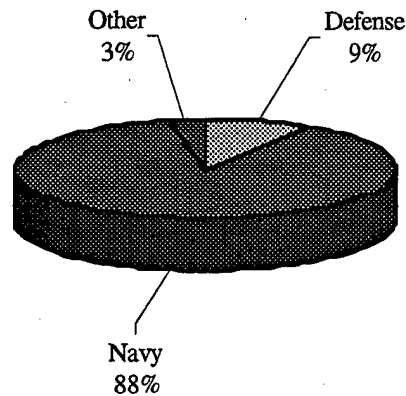


Figure 3. FY98 Sponsor Profile of the Space Systems Academic Group

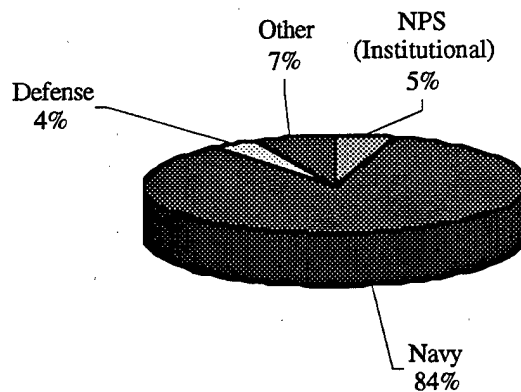


Figure 4. FY98 Sponsor Profile of the Undersea Warfare Academic Group

These are both challenging and exciting times at NPS and the research program exists to help ensure that we remain unique in our ability to provide graduate education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

**COMMAND, CONTROL,
AND
COMMUNICATIONS
ACADEMIC GROUP**

**Dan Boger
Chair**

FACULTY LISTING CC

Boger, Dan C.
Professor and Chair
CC/Bo
831-656-3671 (phone)
831-656-3679 (fax)
dboger@nps.navy.mil

Buddenberg, Rex
Lecturer
IS/Bu
831-656-3576
budden@nps.navy.mil

Channel, Ralph N.
Senior Lecturer
NS/Ch
831-656-2409
nchannell@nps.navy.mil

Davidson, Kenneth L.
Professor
MR/Ds
656-2309/2563
davidson@nps.navy.mil

Gaver, Donald P.
Distinguished Professor
OR/Gv
831-656-2605
dgaver@nps.navy.mil

Gibson John, Lt Col
Instructor
CC/Gj
831-656-1019
jhgibson@nps.navy.mil

Jones, Carl R.
Professor
IS/Js
831-656-2995
cjones@nps.navy.mil

Kemple, William G.
Assistant Professor
CC/Ke
831-656-3309
kemple@nps.navy.mil

Loomis, Herschel H.
Professor
EC/Lm
831-656-3214
loomis@nps.navy.mil

Marvel, Orin E.
Research Associate Professor
CC/Ma
656-3446
opanic@nps.navy.mil

McCormick, Gordon
Associate Professor
CC/Mc
831-656-2933
gmcormick@nps.navy.mil

Mullady, Michael, Lt Col
Curricular Officer
39
831-656-0378
mmullady@nps.navy.mil

Osmundson, John S.
Associate Professor
CC/Os
831-656-3775
josmundson@nps.navy.mil

Parker, Patrick J.
Professor
CC/Pa
831-656-2097
pparker@nps.navy.mil

Porter, Gary R.
Research Assistant Professor
CC/Po
831-656-3772
grporter@nps.navy.mil

Rasmussen, Craig W.
Assistant Professor
MA/Ra
831-656-2763
ras@nps.navy.mil

Roberts, Nancy
Professor
SM/Rc
831-656-2742
nroberts@nps.navy.mil

Wadsworth, Donald v.Z.
Senior Lecturer
EC/Ed
831-656-2115/3456
dwadsworth@nps.navy.mil

GROUP SUMMARY CC

The Command, Control, and Communications (C3) Academic Group is an interdisciplinary association of faculty which consists of 18 faculty members who hold appointments in 8 departments/groups at the Naval Postgraduate School, plus the Curricular Officer. The C3 Academic Group has responsibility for the academic content of the Joint Command, Control, Communications, Computers, and Intelligence Systems curriculum and the Scientific and Technical Intelligence curriculum. C3 Academic Group faculty members carry out research in C4I systems, broadly defined, to support these two curricula.

During 1998, the C3 Academic Group consisted of the following members:

Lieutenant Colonel Michael Mullady, USAF, Curricular Officer
Professor Dan C. Boger (Command, Control and Communications), Chair
Lecturer Rex A. Buddenberg (Information Systems Academic Group)
Professor Ralph N. Channel (National Security Affairs)
Professor Kenneth L. Davidson (Meteorology)
Professor Donald P. Gaver (Operations Research)
Lieutenant Colonel John Gibson, USAF (Command, Control and Communications)
Professor Carl R. Jones (Systems Management)
Associate Professor William G. Kemple (Command, Control and Communications)
Professor Herschel H. Loomis (Electrical and Computer Engineering)
Professor Orin E. Marvel (Command, Control and Communications)
Associate Professor Gordon McCormick (Special Operations Academic Group)
Associate Professor Paul H. Moose (Electrical and Computer Engineering)
Associate Professor John S. Osmundson (Command, Control and Communications)
Professor Patrick J. Parker (Command, Control and Communications)
Associate Professor Gary R. Porter (Command, Control and Communications)
Associate Professor Craig Rasmussen (Mathematics)
Professor Nancy C. Roberts (Systems Management)
Associate Professor Donald v.Z. Wadsworth (Electrical and Computer Engineering)

An overview of the Command, Control, and Communications (C3) Academic Group research program follows.

MAJOR THRUST AREAS OF DOD RESEARCH

In the general area of communications and networks, the Command, Control, and Communications Academic Group continues efforts on the Global Broadcast System. This includes not only performing testing of the broadcast system and channelization but also evaluating what information should flow over the system. This area also includes efforts in combat identification; network analysis support for the combat identification program office is being provided. Another effort in this area is the Internet-to-Sea project, in which an evaluation of alternative ways for Internet capabilities to ships at sea is being done. The final effort in this area is DARPA/DISA Leading Edge Services ATM network project in which alternative ways are being evaluated of utilizing wideband network services, both for operational administrative uses, including evaluation of remote processing of data.

In the general area of decision support, the project in Adaptive Architectures for Command and Control is continuing which is evaluating alternative architectures for C2 structures based on task assignments. This effort continues the long involvement in human-in-the loop experimentation. Support is also being provided to Marine Corps C2 efforts through MCCDC activities. Efforts are also beginning in the Navy Command Center of the Future project; it is expected that evaluation of alternative architectures will be provided for this capability. Interactions with the newly-established C4I Decision Support Center is also being ramped up in order to provide them with modeling and simulation of C2, in general, and specifically C4ISR for precision strike.

In the general area of joint force planning and operations, N-6 and J-6 has requested that the Academic Group participate in numerous exercises and experiments, specifically Fleet Battle Experiments and the Information Superiority Experi-

GROUP SUMMARY CC

ments. Command and control expertise is provided to assist in design and assessment of the experiments. It is anticipated that these efforts will lead to further project work in the above areas.

RESEARCH FACILITIES

The Systems Technology Laboratories (STL) comprise state-of-the-art facilities to support research on current and developmental command and control structures and C4I systems (broadly defined). The vision in developing the STL is to provide researchers access to not only systems which are currently being used by operational forces but also systems which are in development. This vision requires that state-of-the-art networking facilities be maintained within the STL and NPS as well as external to NPS through wideband connectivity. This connectivity is currently provided by a SIPRNET connection and by a connection to the DARPA/DISA Leading Edge Services ATM Network, as well as the NPS backbone.

The Secure STL (SSTL) contains SECRET facilities which support applications in command and control, wargaming and simulation, and communications. In the command and control, the primary application is the Global Command and Control System (GCCS); the installation, except for number of workstations, is identical to those used by the CINCs. The GCCS provides capabilities in reporting, charting, and monitoring of operational forces, and it supports OPLAN preparation and execution via the Joint Operation Planning and Execution System. In wargaming and simulation, the MAGTF Tactical Wargaming System, JANUS, and JPS have been installed. In communications, the Academic Group is the West Coast downlink site for the CONUS test satellite of the Global Broadcast System.

In addition to the SSTL, an unclassified STL and a multimedia lab which is shared with Computer Science is maintained. The unclassified STL provides research support via Internet connectivity and through a wide range of applications programs. The multimedia lab permits researchers to evaluate alternative multimedia applications using both locally-based systems as well as remote systems.

PROJECT SUMMARIES CC

HUMAN CENTERED DESIGN TOOLS

Susan G. Hutchins, Research Assistant Professor
Command, Control, and Communications Academic Group
Sponsor: Naval Submarine Medical Research Laboratory

OBJECTIVE: The objectives of this project are: (a) to define the behavioral components of the command, information, and control (CIC) suite (e.g., cognitive tasks and decision making); (b) review, refine, or develop effective assessment instruments of human system performance in the CIC; (c) apply existing and new models of the CIC with the purpose of enhancing efficiency and reliability while reducing manning through automation; (d) review existing system design processes with respect to determining the utilization of humans and human systems interfaces; and (e) define a human-centered design tool interface that incorporates the results of (a) through (c) to improve the process of designing complex systems.

SUMMARY: Conducted a literature review of the effects of automation on humans, and reported preliminary results for a report to be issued in the first year report. Developed a database as results from various studies were collected to perform a meta analysis. In this technique, the data from different studies of the same or similar effects of automation on humans were analyzed together to obtain further insight on the given effects.

DoD KEY TECHNOLOGY AREAS: Human Systems Interfaces, Command, Control, and Communications

KEYWORDS: Human Factors, Decision Theory, Command, Control, and Communications, Decision Support System, Human Systems Interfaces

CULTURAL ASPECTS OF DECISION MAKING (CADM)

Susan G. Hutchins, Research Assistant Professor
Command, Control, and Communications Academic Group
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: The goal of the CADM program is to develop a decision support system (DSS), to support coalition operations, based on an understanding of current models of decision making and any differences in decision making styles between cultures. Data collection has involved administration of the survey on decision biases and conducting a computer-based experiment on information loss and information ambiguity, and its effects on decision making.

SUMMARY: To date 35 questionnaires have been administered to U.S. military students and 20 to foreign students. Thirty U.S. students have participated in the experiment. Fifty-three foreign students have participated in the experiment. Current plans are for ongoing data collection for FY99.

PUBLICATIONS:

Morrison, J., Kelly, R., Moore, R., and Hutchins, S., "Implications of Decision-Making Research for Decision Support and Displays," *Decision Making Under Stress: Implications for Training and Simulation*, J. Cannon-Bowers and E. Salas, (eds.), Washington, DC, American Psychological Association Books, 1998.

Hutchins, S., Morrison, J., Kelly, R., and Hutchins, R., "Implications of Decision-Making Research for Command and Control," *Naval War College Review*, 1998, in revision.

Hutchins, S. and Hutchins, R., "User-Centered Interface Design of Tactical Aircraft Display," *Proceedings of the 36th Aerospace Sciences Meeting and Exhibit*, American Institute of Aeronautics and Astronautics Paper #98-1036, Reno, NV, 12-15 January 1998.

CONFERENCE PRESENTATIONS:

Hutchins, S. and Hutchins, R., "User-Centered Interface Design of Tactical Aircraft Displays," 36th Aerospace Sciences Meeting and Exhibit, Reno, NV, 12-15 January 1998.

PROJECT SUMMARIES CC

DoD KEY TECHNOLOGY AREAS: Human-System Interfaces, Command, Control, and Communications

KEYWORDS: Human Factors, Decision Theory, Command, Control, and Communications, Decision Support System, Human-System Interfaces

ADAPTIVE ARCHITECTURES FOR COMMAND AND CONTROL (A2C2)

William G. Kemple, Associate Professor

Command, Control, and Communications Academic Group

Sponsors: Office of Naval Research and Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: This is part of a continuing project to conduct field, theoretical, and experimental research to establish a body of knowledge in current and future joint command and control and to develop and test theories of adaptive architectures.

SUMMARY: The A2C2 research project includes an ongoing series of model-based, team-in-the-loop experiments at NPS. Two major experimental activities took place during the reporting year. First, data generated by the third experiment (conducted at NPS in November 1997) was used to examine hypotheses concerning the propensity of organizations, required by an unanticipated event to change their architecture, to select an architecture "close" to the one they are familiar with rather than one "far away," even though the distant one should be superior for the task at hand. Second, the fourth A2C2 experiment was conducted at NPS in August 1998. The third experiment tentatively confirmed the propensity of organizations to select an architecture "close" to the one they are familiar with, but the anticipated superior performance of the distant architecture failed to materialize. Following the model-experiment-model paradigm, the questions examined in the third experiment arose in part from results of the first and second experiments. Similarly, the fourth experiment was designed, among other things, to resolve questions that arose from the third. Analysis conducted so far indicates that the architectures designed to "match" the task do in fact yield superior performance, if the decision-making teams are adequately trained. In addition to A2C2 researchers from NPS and several other sites, over 50 NPS officer-students were involved in experiment four. As with all A2C2 experiments, experiment four provided data to: answer the overall project's research hypotheses, answer research questions at each of the sites involved in the project, support model-data comparisons, and help formulate the research questions to be examined in subsequent experiments. Data generated by the fourth experiment will continue to be analyzed at NPS and the other sites in 1999.

Long range plans for the A2C2 project include transition of research findings to the operating forces. One step toward that goal is the use of a more realistic simulator (e.g., computer-based war game) for selected experiments. The NPS Systems Technology Battle Laboratory and ONR have already combined to procure and install the Marines MTWS war game to support these experiments, among other uses. In 1998, the A2C2 team initiated investigation into the unique requirements of using MTWS for A2C2 experiments. This will include at least one MTWS experiment in 1999.

PUBLICATIONS:

Benson, R., Kemple, W., Kleinman, D., Porter, G., and Serfaty, D., "An Example of Model-Based Empirical Research: A Soup-to-Nuts Evaluation of Alternative C2 Architectures," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, Monterey, CA, June-July 1998.

Hutchins, S.G., Kemple, W.G., Entin, E.E., and Serfaty, D., "Innovative Measures for the Evaluation of Command and Control Architectures," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, Monterey, CA, June-July 1998.

Kemple, W.G., Porter, G.R., Benson, R., Hutchins, S.G., and Hocevar, S.P., "Research in the Classroom and Simulation Laboratory: Combining C2 Research and Education," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, Monterey, CA, June-July 1998.

Hocevar, S.P., "Deciding to Adapt Organizational Architecture: Facilitators and Inhibitors to Change," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, Monterey, CA, June-July 1998.

PROJECT SUMMARIES CC

Hocevar, S.P., Kemple, W.G., and Benson, R., "Translating Model-Based Findings to an Operational Arena: Data Interpretations from Research Participant/Experts," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, Monterey, CA, June-July 1998.

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Hocevar, S.P., Kemple, W.G., Benson, R., and Hutchins, S.G., "Determinants of Organizational Structure From a Military Operations Perspective," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

Hutchins, S.G., Kemple, W.G., Benson, R., and Hocevar, S.P., "Drivers of Adaptation Within Military Architectures: An Empirical Evaluation," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

Kemple, W.G., Kleinman, D.L., Benson, R., Serfaty, D., and Porter, G.R., "Adaptive Architectures for Command and Control (A2C2): The Third Experiment," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

Kemple, W.G., Porter, G.R., Hutchins, S.G., and Hocevar, S.P., "Research in the Classroom and Simulation Laboratory: Combining C2 Research and Education," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June 1998.

Kleinman, D.L. and Serfaty, D., "The DDD - A Team-in-the-Loop Software Tool for Performance Evaluation of Distributed Organizations," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

Hocevar, S.P., "Deciding to Adapt Organizational Architecture: Facilitators and Inhibitors to Change," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June-July 1998.

Hocevar, S.P., Kemple, W.G., and Benson, R., "Translating Model-Based Findings to an Operational Arena: Data Interpretations from Research Participant/Experts," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June-July 1998.

Hutchins, S.G., Kemple, W.G., Entin, E.E., and Serfaty, D., "Innovative Measures for the Evaluation of Command and Control Architectures," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June-July 1998.

CONTRIBUTION TO BOOKS:

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PROJECT SUMMARIES CC

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DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Human Systems Interface

KEYWORDS: Command and Control, Joint Operations, Organizational Experiments

NEW COMMAND, CONTROL AND COMMUNICATION (C3) ANALYSIS TECHNIQUES APPLICABLE TO PROJECT ALBERT MODELING METHODOLOGIES AND MODELS

William G. Kemple, Associate Professor

Command, Control and Communications Academic Group

Sponsor: United States Marine Corps Combat Development Command

OBJECTIVE: To conduct an evaluation of C3 aspects of the Project Albert related modeling methodologies and models, and build upon previous research to develop a set of spatio-temporal measures of combat potentials appropriate to the MAGTF Commander in Operational Maneuver From the Sea (OMFTS) environment that may have applicability to Project Albert modeling methodologies and models.

SUMMARY: This is anticipated to be a continuing project, and it builds upon work done under a previous USMC project. Initial funding was not received until August 1998, but significant progress has been made. Evaluation of modeling methodologies relating to the implementation and integration of spatio-temporal measures of combat potential in existing combat simulators has been conducted and the JANUS model has been selected for initial implementation. Combat potential algorithms have been identified and a code implementation plan prepared. The high resolution PVNT Battlefield Display system has been identified as the most cost-effective platform for demonstrating dynamic spatio-temporal (S-T) displays. Combat scenarios, terrain database, and a presentation development plan have been completed. An engineering report outlining the proposed software modification and demonstration work has been prepared and delivered. Multi-color LOS, range and local topographic information is now available as input to Combat potential calculations. A demonstration CD of combat potential displays on high-resolution 3D terrain is in preparation.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: C2 Measures of Effectiveness, C2 Technology, C2 Evaluation, Command, Control and Communications Analysis Techniques

PUBLICATIONS/PRESENTATIONS CC

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Hocevar, S.P., Kemple, W.G., and Benson, R., "Translating Model-Based Findings to an Operational Arena: Data Interpretations From Research Participant/Experts," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June-July 1998.

Hutchins, S. and Hutchins, R., "User-Centered Interface Design of Tactical Aircraft Displays," 36th Aerospace Sciences Meeting and Exhibit, Reno, NV, 12-15 January 1998.

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PUBLICATIONS/PRESENTATIONS CC

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1998 THESIS ABSTRACTS CC

UPDATING ECONOMIC OPERATIONS IN THE POST INDUSTRIAL AGE

Carl A. Alex-Captain, United States Army

B.A., Saint Leo College, 1983

Master of Science in Defense Analysis, March 1998

Advisor: Gordon H. McCormick, Special Operation Low Intensity Conflict Curriculum Committee

Second Advisor: Gregory Hildebrandt, Department of Systems Management

This thesis addresses the economic aspect of coercive diplomacy to show that new instruments of coercive economic operations created by information age technology: 1) redefine coercive economic operations and 2) that the vulnerabilities and concerns brought about by these new economic instruments change the impact coercive economic operations have on coercive diplomacy. This thesis initially looks to the past, but the intention is to guide continuing future thought on coercive economic operations. This is important for coercive diplomacy because policy makers must be aware that ushered in with present and future technologies are new economic instruments which impact coercive economic diplomacy.

DoD KEY TECHNOLOGY AREA: Other (Coercive Diplomacy, Economic Sanctions)

KEYWORDS: Economic Operations, Economic Coercion, Economic Warfare, Economic Leverage, Economic Sanctions

THE POST COLD WAR CIVIL ENGINEER CORPS: WHAT HAS CHANGED AND WHY?

Tony L. Ammons, Jr.-Lieutenant, United States Navy

B.S.E.E., Virginia Military Institute, 1988

Master of Science in Management-December 1997

Advisors: Richard Doyle, Department of Systems Management

Patrick Parker, Command, Control, and Communications Academic Group

With the end of the Cold War, the military services have experienced significant cuts in endstrength. Within the Navy, the Civil Engineer Corps (CEC) has also experienced some reductions. This thesis sought to determine how CEC endstrength is derived and whether it declined commensurate with overall naval officer endstrength. The command and billet structures for the CEC in 1986 and 1996 were used to represent the Cold War and Post Cold War respectively. The thesis determined how the CEC has changed and compared these changes to those that occurred in the larger naval officer community. One major finding is that CEC endstrength is indirectly affected by Naval officer endstrength and directly affected by the size of the infrastructure. Downsizing the military without downsizing infrastructure results in minor reductions in CEC endstrength. The CEC has experienced a 17 percent reduction in endstrength over the period, with more than 50 percent attributed to the closure of commands. Another finding is that these reductions have not changed the missions of the CEC, construction contract management, facilities maintenance, and advanced base construction.

KEYWORDS: Civil Engineer Corps, Seabees, Military Downsizing

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

CONDUCT AND ASSESSMENT OF A2C2 EXPERIMENT 3 AND GUIDELINES FOR FUTURE EXPERIMENTATION

Robert E. L. Benson-Captain, United States Marine Corps

B.S., United States Naval Academy, 1989

Master of Science in Systems Technology-June 1998

Advisors: William G. Kemple, Command, Control, and Communications Academic Group

Gary R. Porter, Command, Control, and Communications Academic Group

The Adaptive Architectures for Command and Control (A2C2) project is sponsored by the Office of Naval Research (ONR) and is focused on analysis of joint decision-making at the operational level and adaptation of joint command and control

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architectures. To accomplish this objective, the A2C2 project team has conducted a series of human-in-the-loop experiments at the Naval Postgraduate School (NPS). The third experiment of the series was conducted during November 1997. This experiment differed from previous A2C2 experiments in that it focused on how organizations adapt their structure to maximize their effectiveness under changing events. This thesis reports on the planning and conduct of Experiment 3 with a focus on the contributions made by author and the Lead Team of officer-students and the analysis of their hypotheses. The author examines data collected during Experiment 3 in support of these hypotheses. A detailed statistical analysis is performed and results discussed. Finally, a discussion of lessons learned from the author's perspective pertaining to the experiment is given along with recommendations for conducting future experiments at NPS.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Adaptive Architectures for Command and Control (A2C2), Statistical Analysis of Measures of Effectiveness, Human-in-the-Loop Experimentation at NPS

ARTIFICIAL INTELLIGENCE AND FOREIGN POLICY DECISION-MAKING

Russ H. Berkoff-Major, United States Army

B.S., United States Military Academy, 1981

Master of Science in Defense Analysis-December 1997

Advisors: John Arquilla, Information Warfare Academic Group

Christopher Layne, Command, Control, and Communications Academic Group

With the advent of a global information society, the U.S. will seek to tap the potential of advanced computing capability to enhance its ability to conduct foreign policy decision-making. This thesis explores the potential for improving individual and organizational decision-making capabilities by means of artificial intelligence (AI). The use of AI will allow us to take advantage of the plethora of information available to obtain an edge over potential adversaries. Another purpose of this thesis is to give guidance to the software community as to what policymakers will need in order to improve future decision-making processes. The third purpose is to encourage government and private sector decision-makers to allocate adequate resources to actualize the potential of AI. The method of analysis this thesis uses is to examine U.S. foreign policy decision-making on the cognitive or individual, group, and organizational levels. Using the Cuban Missile Crisis and the Yom Kippur War as test beds for critical analysis, identification of both decision enhancing and impeding functions is accomplished. Finally, a counterfactual analytic framework, using an AI model, tests the likely influence of AI on decision-making. The results substantiate the value of AI as both a decision-making enhancer and an impediment reducer for the policymaker. Additional conclusions are derived that improve the decision-making system and its processes by means of introducing an AI capability.

KEYWORDS: Artificial Intelligence, Foreign Policy, Cuban Missile Crisis, Yom Kippur War, Decision-Making, Cognitive Theory, Group Dynamics, Organizational Theory, Bureaucratic Politics, Decision Modeling, Decision-Making

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Modeling and Simulation

1998 THESIS ABSTRACTS CC

DESIGN CONSIDERATIONS FOR FUTURE DECISION SUPPORT SYSTEMS

Francis X. Castellano-Lieutenant, United States Navy

B.S., United States Naval Academy, 1990

Master of Science in Systems Technology-December 1997

Advisors: Susan G. Hutchins, Command, Control, and Communications Academic Group

Orin E. Marvel, Command, Control, and Communications Academic Group

The Navy faces a future of increasingly complex warfare as it continues the shift in emphasis from the open-ocean to the littorals. This complexity arises from the larger number and more difficult nature of missions in littoral environments, plus the increasing sophistication of modern weapons. All of these factors combine to increase the pressure decision-makers will face in making engagement decisions.

By combining the techniques developed in the field of Naturalistic Decision-Making (NDM) with a decision-centered approach to the design of future decision support systems various aspects of the decision-making and execution process can be strengthened to enable decision-makers to react more quickly and confidently to the high tempo warfare they will face. A decision-centered approach to system design and training will support decision-makers in an environment characterized by high stress, ambiguity, and time pressure by enhancing situational awareness and strengthening the steps used to make quick and correct decisions.

The overall impact of a decision-centered approach to system design and training will be a vast increase in the speed of decision-making. This will enable a decision-maker to have the ability to react quickly to take advantage of changing circumstances, to consider a larger set of response options, to forestall enemy options, and to control the overall pace and direction of the conflict.

KEYWORDS: Decision Support Systems, Decision-Making, Tactical Decision-Making Under Stress (TADMUS), Naturalistic Decision-Making (NDM), Speed of Command, Speed of Decision-Making

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

THE UTILITY OF THE ADVANCED SEAL DELIVERY SYSTEM (ASDS) (U)

David E. Chelsea-Lieutenant Commander, United States Navy

B.S., University of California at San Diego, 1987

Master of Science in Defense Analysis-June 1998

Master of Science in Management-June 1998

Advisors: Gordon H. McCormick, Special Operations /Low Intensity Conflict Curriculum Committee

Bard Mansager, Department of Mathematics

The United States Special Operations Command (USSOCOM) is in the process of procuring the Advanced SEAL Delivery System (ASDS), a mini-submersible, to be used by Naval Special Warfare (NSW) forces to conduct maritime special operations. During the development of the ASDS, costs have more than doubled. Consequently, USSOCOM is reevaluating the future of ASDS. This thesis assesses the utility of the ASDS by viewing the ASDS as a part of an "infiltration system" and analyzing the linkages and fit of ASDS within the strategic framework in which it is intended to operate. Modeling the primary factors that define ASDS as a viable special operations platform in high, medium, and low threat environments does this. The output of the model is the capability of ASDS expressed in terms of "mission success." The estimated annual cost of ASDS is also calculated using the current acquisition strategy. In order to compare against current capabilities and their respective costs, this process is repeated for four alternative NSW infiltration systems. Although the ASDS has the highest cost, it is the only system that presents an acceptable probability of mission success in high and medium threat environments. Given NSW's strategic framework, the ASDS has a high utility.

DoD KEY TECHNOLOGY AREAS: Surface/Undersurface Vehicles-Ships and Watercraft, Modeling and Simulation

KEYWORDS: Advanced SEAL Delivery System, Mini-Submersible, ASDS, NSW, USSOCOM, Mission Success

1998 THESIS ABSTRACTS CC

MODELING A JOINT COMBAT IDENTIFICATION NETWORK

Scott A. Davis-Lieutenant, United States Navy

B.S., Purdue University, 1991

Master of Science in Systems Engineering-December 1997

Advisors: John Osmundson, Command, Control, and Communications Academic Group

Gordon E. Schacher, Department of Physics

Today's battlefield is much more heterogeneous than in the past. With the emphasis on joint operations both within the U.S. military and in consort with coalition nations, the need for communications and sharing of tactical information across service and national boundaries has never been greater. A combat identification (CID) network that enables force's positions on the battlefield to be displayed at the appropriate granularity for the various levels of commanders would be a valuable tactical and strategic asset.

This thesis explores the possible network architectures and protocols available to implement such a system and determines, through modeling and simulation, the optimal design to minimize time performance of the flow of information through the network. Using a realistic scenario as a basis, system-engineering principles were used to generate an optimal network architecture from the design parameters chosen. The optimal design was determined to be a network consisting of an Asynchronous Transfer Mode (ATM) access type, asymmetric transmit and receive of messages, and network flow control implementation. Additionally, units on the battlefield should be grouped together by type within a region and the highest bandwidth possible should be used.

KEYWORDS: Combat Identification, Situational Awareness, Combat ID, Network Modeling

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Modeling and Simulation

THE ARSENAL SHIP CONCEPT: VULNERABILITIES TO SPECIAL OPERATIONS

Christian A. Dunbar-Lieutenant, United States Navy

B.S., University of Notre Dame, 1993

Master of Science in Defense Analysis-June 1998

and

Dino Pietrantoni-Lieutenant, United States Navy

B.S., United States Naval Academy, 1991

Master of Science in Defense Analysis-December 1997

Advisor: Wayne P. Hughes Jr., Department of Operations Research

Second Reader: Gordon H. McCormick, Special Operations/Low Intensity Conflict Curriculum Committee

The United States Navy has solicited proposals for a revolutionary class of ship, the Arsenal Ship. Despite reduced funding for the project, the concept is still viable for future development. We show how the development of a new unparalleled weapon system or platform will evoke a response by potential adversaries, based on capabilities and asset investment, by unconventional means. The Arsenal Ship is a target across the spectrum of conflict. This thesis will describe threats that are usually overlooked and examine the Arsenal Ship's vulnerability to them. In addition, we will show how these vulnerabilities arise as the Arsenal Ship operates through the range of geographic areas. Further, this thesis describes possible strategic and tactical defensive actions to enable the Arsenal Ship to counter these unconventional threats. Each recommended action has a direct implication upon the engineered design and the proposed Concept of Operations (CONOP). In addition, the recommendations will influence the strategy for employing any further platform based on the Arsenal Ship concept, anywhere in the world

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, and Control Communications, Conventional Weapons, Surface/Under Surface Vehicles-Ships and Watercraft

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(MAGIF) Tactical Warfare Simulator (MTWS), a detailed and highly realistic stochastic simulation designed to train decision-makers. The author investigated the degree to which Tier I techniques and procedures can be transitioned to Tier II! MTWS by adapting the A2C2 scenario to the MTWS environment. This thesis also discusses extracting experimental data from MTWS.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: A2C2, MTWS, Command and Control, Architectures, Simulation

FOREIGN MILITARY SALES VERSUS DIRECT COMMERCIAL SALES

Metin Gultekin-Lieutenant Junior Grade, Turkish Navy

B.S., Turkish Naval Academy, Istanbul, 1993

Master of Science in Management-September 1998

Advisors: Orin E. Marvel, Command, Control, and Communications Academic Group

John E. Mutt, Department of Systems Management

The transfer of arms from the U.S. to other countries under the Security Assistance Program is done in two basic ways: government-to-government Foreign Military Sales (FMS), and contractor-to-government Direct Commercial Sales (DCS). These methods help to increase standardization and interoperability between the U.S. and its Allies. This study examines the U.S. arms sales policies and procedures for FMS and DCS. It is aimed at identifying the advantages and weaknesses of these methods and to provide information to the Turkish Navy decision-makers for future arms procurements. The objective of this study

is to improve the effectiveness and efficiency of the Turkish Navy in procuring weapon systems/services from U.S. sources.

The research found demonstrates that the choice of either FMS or DCS is driven by the special circumstances of the Turkish Navy, rather than by substantive differences in the two systems. The final decision on procurement methods with the U.S. depends on the country and items to be purchase. This study examines the major trade-offs between the FMS and DCS systems, and recommends the factors which the Turkish Navy should take into account to minimize costs, maximize effectiveness, and maximize efficiency.

DoD KEY TECHNOLOGY AREA: Other (Systems Acquisition Management)

KEYWORDS: Foreign Military Sales, Direct Commercial Sales, Turkish Navy, Arms Sales, Security Assistance

CURRENT AND FUTURE EFFORTS TO VARY THE LEVEL OF DETAIL FOR THE COMMON OPERATIONAL PICTURE

Richard S. Hager-Lieutenant, United States Navy

B.S., United States Naval Academy, 1990

Master of Science in Systems Technology-December 1997

Advisors: Gary R. Porter, Command, Control, and Communications Academic Group

William G. Kemple, Command, Control, and Communications Academic Group

The Joint Staff developed the Command, Control, Communications, Computers, and Intelligence (C4I) for the Warrior Concept in 1992 which stated that the warrior needs a fused, real-time, true representation of the battlespace. To help accomplish this vision, the Global Command and Control System (GCCS) was created. It provides the common operational picture described above, but only down to the unified commander.

This thesis is a comprehensive report that gives a complete review of the current situational awareness systems available to the commander in addition to current and future efforts to bring a common operational picture to all levels of command. The detailed discussions in the thesis of these systems will help students and researchers in the Joint C4I curriculum at the Naval Postgraduate School develop a better understanding of the difficulties in getting a true common operational picture to all services at all levels.

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assist improvement of current response capabilities. Furthermore, the recommendations offer a "model" that can be used to consider the transfer of authority from civilian to military control in times of specific domestic crisis.

DoD KEY TECHNOLOGY AREA: Chemical and Biological Defense

KEYWORDS: Domestic Terrorism, Counterterrorism, Weapons of Mass Destruction, Crisis Management, United States Code, Department of Defense, Department of Justice, Presidential Decision Directive 39, Presidential Decision Directive 62

STUDY OF A STORM: AN ANALYSIS OF ZAPATISTA PROPAGANDA

Angela Maria Giordano-Captain, United States Army

B.S., United States Military Academy, 1987

Master of Science in Defense Analysis-December 1997

Advisors: Gordon H. McCormick, Command, Control, and Communications Academic Group
Roman Laba, Department of National Security Affairs

The beginning hours of 1994 rang in both the New Year and the Zapatista uprising in Chiapas. Although in existence since 1983, the Zapatista movement was relatively unknown to the rest of the world until *Subcomandante Marcos*' propaganda offensive against the Mexican government. Steeped in historical references to indigenous exploitation and Emiliano Zapata, the Zapatista's call to arms and governmental reformation has continued to make effective use of symbols and rituals, reshaping the images of Indianness and economic suffering within Chiapas. The organization continues to garner support abroad as well as within Mexico through the use of the Internet, public media, and effective appropriation of nationalist symbols. What marks the Zapatista rebellion as extraordinary is its emergence as one of the first information age insurgencies to make such efficient use of these mediums.

This study presents a framework for analyzing propaganda, drawing from the fields of symbolic politics, cultural anthropology, and marketing. This symbolic frame is then applied to the Zapatistas in order to better understand the entire movement. The propaganda goals of the organization are examined, specifically addressing the areas of legitimacy, member unification, support both outside and within Mexico, recruitment, and challenges presented to the government.

KEYWORDS: Propaganda, Zapatistas, Ejercito Zapatista de Liberacion Nacional (EZLN), Symbolology, Mexico, Target Audiences, Insurgency, Rebellion

DoD KEY TECHNOLOGY AREA: Other (Psychological Operations/Special Operations)

ADAPTING THE MARINE AIR GROUND FORCE TACTICAL WARTIME SIMULATOR FOR USE WITH THE A2C2 EXPERIMENT

Davis F. Greenwood-Captain, United States Air Force

B.S., University of Maine, 1992

Master of Science in Systems Technology-June 1998

Advisors: William Kemple, Command, Control, and Communications Academic Group
Gary Porter, Command, Control, and Communications Academic Group

The goals of the Office of Naval Research sponsored Adaptive Architectures for Command and Control (A2C2) research project are to study current and future joint command and control (C2) issues and develop theories about adaptive C2 architectures. The project includes three tiers of model-based human-in-the-loop experiments ranging from ones using simple, highly abstract computer-based simulations (Tier I), through more complex, realistic simulations (Tier II), to involvement in wargames and operational experiments (Tier III). Three Tier I experiments have been conducted to date, and a fourth is in planning. All have employed the Distributed Dynamic Decision Making III Simulation, developed for this type of experiment, and all have involved variants of the same amphibious scenario. The purpose of this thesis is to help the A2C2 research team prepare for Tier II experiments. The target platform for Tier II is the Marine Air Ground Task Force

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DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications; Modeling and Simulation

KEYWORDS: Collaborative Planning

**POACHING AND COUNTERPOACHING IN SUB-SAHARAN AFRICA:
A STRATEGY FOR ENGAGEMENT, DEVELOPMENT, AND PROTECTION**

James A. Emmert-Lieutenant, United States Navy

B.A., University of Missouri Columbia, 1988

Master of Science in Defense Analysis-December 1997

and

John P. LaDelfa-Major, United States Army

B.S., Norwich University, 1986

Master of Science in Defense Analysis-December 1997

Advisor: Gordon H. McCormick, Command, Control, and Communications Academic Group

Second Reader: Christopher Layne, Command, Control, and Communications Academic Group

The purpose of this thesis is to define the poaching problem in sub-Saharan Africa, to provide for the development of solutions, and to illustrate the significance of the problem to both Africa and the United States. This objective is achieved by illustrating the similarities between poaching and insurgency, developing a typology for the classification of different forms of poaching, and applying an insurgency/counterinsurgency model to these scenarios. Additionally, by addressing the negative effects poaching has on economic, political, and social issues we demonstrate that poaching is a problem that extends beyond the loss of selected animal species.

Through the application of our model to actual cases of poaching, we demonstrate the utility of drawing upon insurgency theory for providing solutions to the poaching problem. As a result, this thesis offers an atypical approach for systematically conceptualizing and implementing effective counterpoaching strategies. After developing a framework for analytically thinking about the poaching problem, we make recommendations regarding the role of specific U.S. forces within a comprehensive strategy of engagement. Finally, we comment on the importance of defining strategies whose methods of implementation are aligned with the desires, limitations, and capabilities of the host nation.

KEYWORDS: Environmental Security, Counterinsurgency, SOF Missions Wildlife Poaching

DoD KEY TECHNOLOGY AREAS: Other (Environmental Security, Counterinsurgency, SOF Missions)

**DOMESTIC TERRORISM AND WEAPONS OF MASS DESTRUCTION: AN
EVALUATION OF INTERAGENCY RESPONSE CAPABILITIES (A USER'S GUIDE) (U)**

George M. Fraser-Major, United States Army

B.A., California State University, 1987

Master of Science in Defense Analysis-September 1998

and

Mark F. Hinch-Lieutenant, United States Navy

B.A., New Hampshire College, 1988

Master of Science in Defense Analysis-December 1998

Advisor: Gordon H. McCormick, Special Operations/Low Intensity Conflict Curriculum Committee

Second Reader: Erik Jansen, Department of Systems Management

The purpose of this thesis is to analyze and identify existing and potential flaws that inhibit integration of civilian and military agencies in response to domestic terrorist threats involving weapons of mass destruction (WMD). The study reviews the existing counterterrorism legal and institutional frameworks in conjunction with current interagency coordination mechanisms. The subsequent analysis of these areas revealed strengths and weaknesses that influence interagency response to domestic WMD terrorism. Corresponding recommendations for review and implementation are provided to

1998 THESIS ABSTRACTS CC

KEYWORDS: Arsenal Ship, ARSHIP, Maritime Special Operations, and Special Operations, Combat Swimmer, VBSS, Visit Board Search and Seize, Unconventional Warfare.

THE EXPLOITATION OF OVERHEAD SURVEILLANCE AND RECONNAISSANCE IN SUPPORT OF NAVAL SPECIAL WARFARE

Christian A. Dunbar-Lieutenant, United States Navy

B.S., University of Notre Dame, 1993

Master of Science in Space Systems Operations-June 1998

Advisors: Richard C. Olsen, Department of Physics

Dan Boger, Command, Control, and Communications Academic Group

Naval Special Warfare (NSW) operations have historically received a poor level of intelligence support. The importance of timely and comprehensive intelligence is paramount to these operations' tactical and strategic success. This lack of support stems from a lack of understanding by the Intelligence Community of the Essential Elements of Information that are requested by NSW and from a lack of knowledge by the NSW operators about existing systems and their capabilities and limitations. This report focuses on the Intelligence disciplines of Imagery Intelligence (IMINT) and Signals Intelligence (SIGINT). The presentation of this report focuses on educating both the user and the provider to the unique applications of these disciplines that will refine this *essential combat resource* into an effective and integral part of NSW operations. This report contains real world examples of existing and emerging systems.

The conclusions of this report address the necessity for early training of the junior officer corps of the NSW community. These are the operational leaders that will be directly effected by proper exploitation of this combat resource. This resource must also be the focus of NSW senior leadership in order for them to effectively support *forwardly deployed strategic warfighters*.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Intelligence)

KEYWORDS: Signals Intelligence, Imagery Intelligence, Requirements Process, Naval Special Warfare

AN ANALYSIS OF BANDWIDTH REQUIREMENTS FOR COLLABORATIVE PLANNING

Michele A. Duncan-Lieutenant Commander, United States Navy

B.S., Old Dominion University, 1984

Master of Science in Systems Technology-June 1998

Advisors: John Osmundson, Command, Control, and Communications Academic Group

Dan C. Boger, Command, Control, and Communications Academic Group

Any military operation, no matter how large or small requires some level of planning. Planning has become more complicated, requiring more interactions across geographical, functional, and organizational boundaries in a more compressed command and control decision cycle. For ships at sea, conducting planning with other units, at sea or on shore, is constrained by the availability of communications bandwidth and limitations of the tools used for real-time interactions. Emerging tools such as audio and video conferencing and shared whiteboard, enable real-time collaboration among dispersed forces, however, these tools are bandwidth "greedy," requiring more than is currently available on many ships. In an effort to determine what amount of bandwidth a ship needs, this thesis used simulation and modeling to experiment with combinations of bandwidth, collaboration tools, the number of planners, and the network delivery method used. In general, a bandwidth of 128 kbps enables two ships to conduct a video and audio session. Using multicast network delivery, 256 kbps enables a ship to collaborate with five other sites, and at 384 kbps, a ship can conduct a whiteboard with video and audio with up to eight other sites.

1998 THESIS ABSTRACTS CC

KEYWORDS: Global Command and Control System, Common Operational Picture, Situational Awareness, C4I, Command and Control, Battlespace Management

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

ISRAELI NUCLEAR WEAPONS AND WAR IN THE MIDDLE EAST

James D. Harden-Major, United States Air Force

B.S., United States Air Force Academy, 1983

Master of Science in Defense Analysis-December 1997

Advisors: Christopher Layne, Command, Control, and Communications Academic Group,

Peter R. Lavoy, Department of National Security Affairs

This thesis examines the influence of the Israeli nuclear weapons capability on conflict in the Middle East. There are two perspectives regarding the impact of nuclear proliferation on strategic stability. Three paths to strategic instability are examined: preventive attacks, preemptive attacks, and the escalation of conventional conflict to nuclear war. The optimistic perspective argues that nuclear weapons make preventive and preemptive attacks less likely, and keep conventional conflict from escalating to nuclear war. The pessimistic perspective argues the opposite—that nuclear weapons make preventive and preemptive attacks more likely, and raise the likelihood of escalation to nuclear war. My analysis of the Israeli cases shows that “opaque” nuclear proliferation decreases the pressure for preventive attacks, increases the chances for miscalculation, and creates sufficient concern about nuclear weapons to reduce the likelihood of preemptive attacks. Two factors help reduce the risk of nuclear proliferation as posed by proliferation pessimists, opaque nuclear weapons programs and nondeclaratory nuclear weapons policies. The implication of this research is that if the United States cannot dissuade a country from going nuclear, it should reinforce its incentives to maintain opacity and a nondeclaratory policy. Particular attention should be given to states which resist these efforts, as they represent the greatest risk of nuclear weapons use.

KEYWORDS: Israel, Nuclear Proliferation, Arab-Israeli Conflict, National Security Affairs

DoD KEY TECHNOLOGY AREA: Other (Nuclear Weapons)

LOW-END SOLUTIONS TO THE UNDERGROUND DILEMMA

Brian M. Hayes-Captain, United States Army

B.S., Suffolk University, 1986

Master of Science in Defense Analysis-December 1997

and

David A. Roddenberry Jr.-Major, United States Army

B.S., Western Carolina University, 1986

Master of Science in Defense Analysis-December 1997

Advisors: John Arquilla, Information Warfare Academic Group

Gordon H. McCormick, Command, Control, and Communications Academic Group

Both the 1981 Israeli Raid on the Osirak nuclear reactor in Iraq and the Gulf War, served notice to would-be proliferators that, in order to survive in the face of the conventional superiority of the United States and its allies, means must be developed to protect those assets deemed valuable or strategic in nature. Many would-be proliferators have chosen to develop underground structures, referred to as hardened and deeply buried targets (HDBT), as the preferred means to protect and hide their efforts to obtain weapons of mass destruction (WMD). To counter this trend, the U.S. relies almost entirely upon a policy of negotiated peacetime elimination or reduction of WMD/HDBT through diplomatic channels. Yet, if these efforts fail and the necessity for preemption or prevention emerges, instead of immediately relying on direct force alternatives, an indirect low-level interdiction method may be both more appropriate and available.

This thesis explores an alternative means by which the vulnerabilities of HDBT/WMD sites may be exploited through the use of low-level, indirect, counter-force strategies. This exploration of alternative HDBT interdiction approaches con-

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cludes that low-level counterforce strategies can complement existing counterproliferation initiatives, when employed as components of an overall campaign designed to deny and disrupt a would-be proliferator's progress.

KEYWORDS: Counterproliferation, Hardened and Deeply Buried Targets (HDBT)

DoD KEY TECHNOLOGY AREA: Other (Weapons of Mass Destruction)

DECISION AIDS IN AIRBORNE COMMAND AND CONTROL PLATFORMS

Karl E. Hines-Lieutenant, United States Navy

B.S., United States Naval Academy, 1990

Master of Science in Systems Technology-June 1998

Advisors: Orin Marvel, Command, Control, and Communications Academic Group

Gary Porter, Command, Control, and Communications Academic Group

As a result of dramatic growth in the capabilities of C4I systems, commanders have an immense amount of information available to them. Increased bandwidths and improved speeds in our communications systems can overload our commanders with data. One solution is improved methods of presenting information to the commander.

The same advances that threaten to overload the commander with data provide a solution. Improved technology now allows us to present the information in an easily assimilated graphical, 3D or "picture" form. These new types of displays can present the information in an intuitive style that eases the commander's cognitive workload and speeds comprehension. Recent studies comparing different types of displays support this theory.

Because commanders in airborne command and control platforms require a detailed understanding of a three dimensional environment, they should adopt some type of 3D display. Perspective or 2D displays are not perfect for absolutely every situation the commander will face; but the added understanding of the action, tactics and intentions of friendly and enemy forces demand its adoption.

DoD TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Computing and Software, Human Systems Interface

KEYWORDS: Decision Aids, Command and Control (C2), Display, E-2C Hawkeye, Three Dimensional Displays

GREAT POWERS, WEAK STATES, AND ASYMMETRIC STRATEGIES

Michael R. Lwin-Captain, United States Army

B.S., Georgetown University, 1989

Master of Science in Defense Analysis-December 1997

Advisors: John Arquilla, Information Warfare Academic Group

Christopher Layne, Command, Control, and Communications Academic Group

On the verge of the twenty-first century, America finds itself in the position of a great power with dominant military technology. This thesis examines the possibility that weaker states may be able to strategically innovate and defeat us in war despite our technological advantages. The purpose of the thesis is to survey what type of strategic innovations, also known as asymmetric strategies, are possible and to examine the conditions under which they may be successful.

This thesis begins by defining asymmetric strategies using a comprehensive model of strategy developed by Rear Admiral J.C. Wylie. The thesis also examines four variables which may explain the success or failure of asymmetric strategies. To illustrate possible asymmetric strategies and examine the contextual conditions under which they work, the thesis considers the cases of the Italo-Ethiopian war of 1935-36, the Russo-Finnish War of 1939-40, and the American-North Vietnamese War of 1965-73. The thesis finds that the four variables have significant explanatory power for the success or failure of these strategies. The thesis concludes by examining strategic implications for the United States, both as a possible opponent of weak states and as a supporter of a weak state faced by a great power threat.

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KEYWORDS: Strategy, Strategic Innovation, Asymmetric Conflict and Military Technology, Future Wars, Italo-Ethiopian War, Russo-Finnish War, Vietnam

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Conventional Weapons, Other (Strategy)

INFLUENCE MODELING STATE-TERRORISM FOR INFORMATION OPERATIONS (U)

Russell L. Marsh-Lieutenant, United States Navy

B.S., Oregon State University, 1994

Master of Science in Systems Engineering-September 1998

Advisor: CAPT James R. Powell, Information Warfare Academic Group

Second Reader: Gordon McCormick, Special Operation Low Intensity Conflict Curriculum Committee

The purpose of this research is to use Situational Influence Assessment (SIAM) Module created by SAIC to model a terrorist organization that is attempting to disrupt negotiations between two state actors. The SIAM model was used to analyze the causal relationships and to look for the various leverage points at which to apply Information Operations (IO) that will minimize the effects of terrorist action, and influence the terrorists decision making process. The actors in a specific scenario were modeled as to how leadership could be influenced. After analysis with SIAM, possible IO options were created, incorporated into the model and tested to see how effective the IO options were at influencing the decision-making process. Once the IO options had been tested, a suggested plan of action results. Both a preventative approach and reactive approach are proposed. The preventative approach is intended to reduce the effectiveness of terrorism and impede the conduct of the terrorist organization. The reactive approach provides options for responding to terrorist activities without alienating the surrounding populace.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: SIAM, Terrorism, Information Operations, Peace Negotiations

NAVY SEALS: THEORY VS. REALITY

Brian W. Reeves-Lieutenant, United States Navy

B.S., University of South Carolina, 1986

Master of Science in Defense Analysis-December 1997

Advisor: Gordon H. McCormick, Command, Control, and Communications Academic Group

Second Reader: Bard K. Mansager, Department of Mathematics

The purpose of this thesis is to examine two books that advance alternate theories to explain the success or failure of special operations. The first book is *Perilous Options: Special Operations as an Instrument of U.S. Foreign Policy*, by Lucien S. Vandenbroucke. Vandenbroucke discusses recurrent problems with U.S. special operations and identifies what he believes are the causes of failure of such operations. The second book is *Spec Ops*, written by William H. McRaven. McRaven examines eight historic cases from around the globe and develops his theory on how to conduct successful special operations. From the analysis of three recent Navy SEAL's special operations missions, both theories seem to provide a useful tool for thinking about the failure or success of special operations. Combining these theories provides a complete framework for senior planners and tacticians in formulating a plan for successfully conducting future special operations missions.

KEYWORDS: SEALs, Urgent Fury, Just Cause, Desert Storm

DoD KEY TECHNOLOGY AREA: Other (Special Operations)

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CONVERT SUBMARINE COMMUNICATIONS USING EXTRA HIGH FREQUENCY (EHF) TRANSMISSIONS (U)

Drew J. Reiner-Lieutenant, United States Navy

B.S., United States Naval Academy, 1991

Master of Science in Systems Technology-December 1997

Advisors: Daniel Boger, Command, Control, and Communications Academic Group

Donald Wadsworth, Space Systems Academic Group

This thesis quantifies the detectability of a transmitting U.S. nuclear submarine that is using EHF communications. This is done using a communications link analysis that is performed by circular equivalent vulnerability radius (CEVR) computer algorithm that displays its results in polar graph format. CEVRs for two different communication suites under alternative scenarios are calculated. Furthermore, by performing such an analysis onboard a submarine in precarious waters, the necessary real-time information for evaluating the risk of using such EHF communication transmissions would be available instantaneously.

KEYWORDS: Submarine, EHF, Communication

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

ANALYZING COMMUNICATION ARCHITECTURES USING COMMERCIAL-OFF-THE-SHELF (COTS) MODELING AND SIMULATION TOOLS

Alan R. Rieffer-Lieutenant Commander, United States Navy

B.S., University of Arizona, 1982

Master of Science in Systems Technology-June 1998

Advisors: John Osmundson, Command, Control, and Communications Academic Group

Donald Wadsworth, Command, Control, and Communications Academic Group

There are many initiatives focused towards the pursuit of information systems capabilities—hardware, software, and architecture—and other technologies that will markedly enhance the command and control (C2) function. The overarching purpose of this thesis is to provide joint task force communication planners with the tools for planning and managing the increasing communications demand. To this end, this project had two goals, to compare the performance of two computer-aided modeling and simulation tools representing both ends of the cost and complexity spectrum, and to provide a subjective evaluation. Four computer models were developed to simulate Information Technology for the 21st Century (IT-21) and Joint Tactical Information Distribution System (JTIDS) networks using OPNET Modeler/Radio, by MIL3, and EXTEND by Imagine That, Inc. Although assumptions were made to simplify the models, simulation runs demonstrated that the network models developed using OPNET and EXTEND produced very similar and believable results. The JTIDS models results for data rate and message latency agreed within 3.5%. Similarly, IT-21 system models detected changes and trends caused by different system loads. The results indicate that low cost, commercial off-the-shelf modeling tools can be used to describe various networks used in joint operations.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: JTIDS, Link-16, IT-21, EXTEND, OPNET, Modeling and Simulation, Command and Control, Architectures, Simulation

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KOREAN UNIFICATION: A UNITED STATES ARMY SPECIAL FORCES FRAMEWORK FOR EMPLOYMENT

Paul D. Rounsaville-Captain, United States Army

B.S., Oklahoma State University, 1987

Master of Science in Defense Analysis-December 1997

**Advisors: Edward A. Olsen, Department of National Security Affairs,
Christopher Layne, Command, Control, and Communications Academic Group**

As Korea approaches unification, the growing stability problems in the north create questions about how these problems can be approached to avoid destabilizing the peninsula upon unification. This thesis predicts and analyzes the significant stability and support operations likely to confront the Republic of Korea (ROK) Army during post-conflict or post-unification proceedings, and presents an employment framework for United States Army Special Forces (USASF) designed to support the ROK Army's efforts. The employment framework is designed to complement a theater-level strategic plan for conducting stability and support operations (SASO) in the north occurring along a suggested spectrum of unification possibilities. The framework consists of three elements: the SASO missions predicted, framework doctrinal elements, and four Korean unification scenarios. Doctrinal elements include the operations, missions, and unique roles USASF conduct during SASO. The utility of this thesis is the analysis of framework doctrinal elements in relation to the SASO missions and unification environment that may confront USASF while supporting the ROK Army in successful completion of these missions. The USASF employment framework is intended to be used as an aid for U.S. military planners at the strategic, operational and tactical levels during the deliberate planning process for post-conflict or post-unification operations in the north.

KEYWORDS: Korean Unification, United States Army Special Forces, Stability and Support Operations

DoD KEY TECHNOLOGY AREAS: Other (Force Employment and Stability, Support Operations)

THE DEVELOPMENT OF A LITTORAL REGION AREA COMMUNICATIONS NETWORK IN SUPPORT OF OPERATIONAL MANUEVER FROM THE SEA

Bryan J. Smith-Major, United States Marine Corps

B.S., University of Arizona, 1982

Master of Science in Information Technology Management-September 1998

**Advisors: Rex A. Buddenberg, Information Systems Academic Group
John Osmundson, Command, Control, and Communications Academic Group**

Despite the apparent abundance of modern communication technology such as satellites, computers, and fiber-optic transmission systems, communication capacity is a limited resource for littoral operations. The Navy and Marine Corps lack the dedicated networks to support such doctrinal concepts as Operational Maneuver From the Sea (OMFTS). One solution is to develop a Littoral Region Area Network (LRAN). The primary goal of this thesis is to underscore the littoral operating environment and bandwidth requirements. It also investigates reliable seaborne network communication systems complementary to satellite and wireless networks, and proposes an open, standards-based modular architecture, utilizing a network centric design model as the basis for LRAN. It employs modeling and simulation techniques to demonstrate coupling of the system integration processes with the doctrinal concepts of OMFTS.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Other (Information Technology)

KEYWORDS: Networks, Aerostats, Littorals, Operational Maneuver from the Sea (OMFTS), Communications, Modeling and Simulation, IEEE 802.11, ADNS, Marine Corps Tactical Data Network

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ANALYSIS OF NATIONAL OVERHEAD INTELLIGENCE COLLECTION (U)

Randall L. Smith-Lieutenant, United States Navy

B.S., United States Naval Academy, 1989

Master of Science in Space Systems Operations-March 1998

Advisors: Dan Boger, Command, Control, and Communications Academic Group

Carl Jones, Information Sciences Academic Group

Space systems provide wide-ranging support to the military and the National Command Authority (NCA) during any developing crisis. This thesis explores how the national systems responded to such an event against the geopolitical backdrop of world events. Each system architecture's capability and role is examined in detail. The entire satellite process is covered from the tasking process and distribution of assets through the dissemination of information to NCA decision makers and on scene military commanders.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Other (Intelligence)

KEYWORDS: Signals Intelligence, Imagery Intelligence, Requirements Process

COMMAND IN THE 21ST CENTURY: AN INTRODUCTION TO CIVIL-MILITARY RELATIONS

Edward R. Taylor-Captain, United States Marine Corps

B.S., United States Naval Academy, 1992

Master of Science in Systems Technology, June 1998

Advisors: Dan C. Boger, Command, Control, and Communications Academic Group

Lt Col John H. Gibson, Command, Control, and Communications Academic Group

This thesis serves as an introduction to civil-military relations and the just war tradition for Joint Command, Control, Communications, Computers, and Intelligence (C4I) students taking CC3000 or an equivalent course. The goal of this thesis is to provide the student with a broad understanding of these subjects. The author intends this thesis to be used as a supplementary reading in CC3000.

This thesis addresses the following: professionalism and its relationship to the study of civil-military relations, the roles of the military in society, civilian control and the various schools of thought associated with it, historical and legal precedents for the American civil-military relationship, the just war tradition, various issues affecting current and future civil-military relations in the United States, the impact of military operations other than war (MOOTW) on civil-military relations and the military ethos, and, finally, the applicability of the just war tradition to the MOOTW environment.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Command, Civil-Military Relations, Just War Tradition

APPLICATIONS OF JOINT TACTICAL SIMULATION MODELING

Steve VanLandingham-Lieutenant, United States Navy

B.S., United States Air Force Academy, 1992

Master of Science in Defense Analysis-December 1997

Advisor: Bard K. Mansager, Department of Mathematics

Second Reader: Gordon H. McCormick, Command, Control, and Communications Academic Group

Advances in technology allow Computer Simulation Models (CSM) to be used as a powerful tool to aid military decision-makers. This thesis explores the usefulness of one of these models, the Joint Tactical Simulation (JTS). First, this thesis outlines the information and tasks required to run JTS, which will give the reader a basic understanding of the program and how much effort it requires. Next, it describes the scenario presented in this thesis by detailing the methodology of terrain

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development, listing the assets required and the mission concept employed. It concludes by discussing some of the advantages and disadvantages of JTS followed by a reevaluation of the simulation and its possible uses.

The concluding appendix is a tutorial that guides the reader through an amphibious assault modeled on the UNIX-based computer systems at the Naval Postgraduate School's (NPS) Secure Systems Technology Laboratory. It was designed to be accomplished in less than four hours and give the user an opportunity to run a simulation while conducting minimal interaction.

KEYWORDS: Joint Tactical Simulation, Naval Special Warfare, High Resolution Models

DoD TECHNOLOGY AREA: Modeling and Simulation

ANALYSIS OF THE DIGITAL VIDEO BROADCAST STANDARD FOR USE IN THE GLOBAL BROADCAST SERVICE ARCHITECTURE

Robert M. Wellborn-Captain, United States Army

B.A., New Mexico State University, 1987

Masters of Science in Information Technology Management-March 1998

Advisor: Paul H. Moose, Command, Control, and Communications Academic Group

Second Reader: Michael W. Boudreau, Department of Systems Management

The demand for robust, space based, communication systems, for the Department of Defense, continues to increase. The proposed architecture for the Global Broadcast Service (GBS) will meet many of these demands. GBS is a Department of Defense CONUS-based Direct Broadcast Satellite (DBS) project utilizing commercial-off-the-shelf components for the transmission and reception of video, Internet Protocol (IP) and Asynchronous Transfer Mode (ATM) data transmissions. The satellite transmission standard plays a key role in the success of the GBS program. In November 1997 the GBS prime contractor, Hughes Information Systems, announced the use of the Digital Video Broadcast (DVB) standard as the satellite transmission standard for GBS.

This thesis presents an independent evaluation supporting the use of the DVB standard within the GBS architecture. Data contained in this thesis evaluates the theoretical effectiveness of the GBS system while using the DVB transmission standard. This thesis contains a comparison of the DVB supporting documentation against the GBS requirements documentation. The conclusions of this thesis strongly support selection of the DVB standard as the satellite transmission standard for GBS.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Manufacturing, Science and Technology, Space Vehicles

KEYWORDS: Global Broadcast Service, Command, Control, and Communication Systems, Direct Broadcast Satellites,

**INFORMATION SYSTEMS
ACADEMIC GROUP**

**Dan Boger
Chair**

FACULTY LISTING IS

Boger, Dan C.
Professor and Chair
IS/Bo
831-656-3671 (phone)
831-656-3679
dboger@nps.navy.mil

Bhargava, Hemant
Associate Professor
SM/Bh
831-656-2264
bhargava@cs.nps.navy.mil

Brady, Terrence
Senior Lecturer
SM/Ba
831-656-3470
tbrady@nps.navy.mil

Buddenberg, Rex
Lecturer
SM/Bu
831-656-3576
budden@nps.navy.mil

Dolk, Daniel R.
Professor
SM/Dk
831-656-2260
drdolk@nps.navy.mil

Jones, Carl R.
Professor
SM/Js
831-656-2994
cjones@nps.navy.mil

Kamel, Magdi N.
Associate Professor
SM/Ka
831-656-2494
mkamel@nps.navy.mil

Schneidewind, Norman F.
Professor
SM/Ss
831-656-2719
schneidewind@nps.navy.mil

Sengupta, Kishore
Associate Professor
SM/Se
831-656-3212
kishore@nps.navy.mil

Sridhar, Suresh
Assistant Professor
SM/Sr
831-656-2489
sridhar@nps.navy.mil

DEPARTMENT SUMMARY IS

The Information Systems Academic Group was formed in response to conversations with the Director of Space Information Warfare, Command, and Control (N6). Coupled with the overall impact of C4ISR systems in the military environment and the creation of Network Centric Warfare, concern for better utilization and flexibility in assigning officers in graduate education coded billets prompted N6 and NPS to create a uniquely tailored Information Sciences, Systems, and Operations curriculum. This new curriculum, with specializations in Computer Science; Joint Command, Control, Communications, and Intelligence Systems; Space Systems Operations; Information Technology Management; Modeling, Virtual Environments, and Simulations; Information Warfare; and a Professional Practice Core, is designed to serve warfighters and technical support officers with knowledge and understanding as follows:

- Understand and innovatively create, maintain, and operate doctrine, systems, and procedures to assure our Information Superiority.
- Understand and innovatively develop and implement command and control decision processes in organizations to assure Information Superiority.
- Understand and innovatively employ Science and Technology in creating systems for Information Superiority.

PROJECT SUMMARIES IS

UNITED STATES MARINE CORPS MANPOWER MODELING ENVIRONMENT

Hemant Bhargava, Associate Professor

Information Systems Academic Group

Sponsor: Deputy Chief of Staff (Manpower and Reserve Affairs), U.S. Marine Corps

OBJECTIVE: The U.S. Marine Corps' Manpower and Reserve Affairs Department is undergoing the development of a new generation of software to support the manpower modeling process. Building on previous analysis of the department's existing models and modeling technologies, the focus was on the redevelopment of models for routine job assignments of enlisted Marines and distribution of recruits to training schools.

SUMMARY: A decision support system was developed for recruit distribution in the U.S. Marine Corps. The system implements a basic assignment model. Its main contribution is in allowing the model manager to game the system and in methods for measuring and comparing quality of alternative solutions. The system has a complete user interface as well as connections to existing Marine Corps databases for obtaining problem inputs and for exporting solutions.

PUBLICATION:

Bhargava, H.K. and Snoap, K.J., "Re-Engineering Recruit Distribution in the U.S. Marine Corps," *Interfaces*, September 1998, submitted.

THESES DIRECTED:

Koch, G., "Re-Engineering the United States Marine Corps' Enlisted Assignment Model (EAM)," Master's Thesis, Naval Postgraduate School, June 1998.

Snoap, K., "Re-Engineering the United States Marine Corps' Recruit Distribution Model (EAM)," Master's Thesis, Naval Postgraduate School, September 1998.

OTHER:

Bhargava, H., RDdss: Decision Support System Software for Recruit Distribution, (delivered and installed at USMC Manpower and Reserve Affairs).

Bhargava, H., EAM-NPS: Optimization Model and Solver Software for Enlisted Assignment.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Manpower Modeling, Modeling Languages, Decision Support Systems

GENETIC STORMS: INVESTIGATING PERSIAN GULF ILLNESSES

Hemant Bhargava, Associate Professor

Information System Academic Group

Sponsor: Office of the Assistant Secretary of Defense (Health Affairs)

OBJECTIVE: The Comprehensive Clinical Evaluation Program (CCEP) database contains demographics, attributes, and results of comprehensive medical evaluations on Persian Gulf War veterans. The purpose of this research is to apply conventional and emerging data analysis techniques to the CCEP database, aiming to discover relationships and patterns that may provide answers to health problems reported by Persian Gulf War veterans.

PROJECT SUMMARIES IS

SUMMARY: In analyzing the Gulf War syndrome, a novel approach was developed — involving an encoding and solution using a genetic algorithm - to knowledge discovery in large (high-complexity) databases. As a result, there is a general purpose system for exploratory data analysis of such databases.

PUBLICATIONS:

Bhargava, H.K., "Data Mining by Decomposition: Adaptive Search for Hypothesis Generation," *INFORMS Journal on Computing*, last revised September 1998, to appear.

Bhargava, H.K. and Carter, J., "Evolutionary Search Heuristics for Exploratory Data Analysis," *Proceedings of the 6th INFORMS Computer Science Technical Section Conference on Computer Science and Operations Recent Advances in the Interface*, Monterey, CA, 7-9 January 1998.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Data Analysis)

KEYWORDS: Gulf War Syndrome, Genetic Algorithms, Exploratory Data Analysis, Heuristic Search

MANPOWER MODEL INTEGRATION AND PERSONNEL BATTLEFIELD SIMULATION

Daniel R. Dolk, Professor

Information Systems Academic Group

Sponsor: Naval Personnel Research and Development Center

OBJECTIVE: To develop an overall research plan for proceeding with the Manpower Model Integration project which will include details on building an initial prototype for the Personnel Battlefield Simulation (PBS) decision support team.

SUMMARY: The purpose of this project was to identify a decision support system (DSS) development plan for the Naval Personnel Battlefield Simulation (PBS) concept. The PBS is intended to be a multi-player simulation game environment allowing Navy decision-makers to examine the impact of different manpower policy decisions in the areas of recruiting, assignment and distribution, training, community management, and force structure. A preliminary step is to design a system which integrates various mathematical manpower models and associated data into a data warehouse-driven DSS based upon manpower readiness metrics. The work done in this stage of the project was to identify which models should be integrated, what their associated metrics are, and what data are required to implement a warehouse of these metrics.

PUBLICATION:

Dolk, D.R., "Integrated Model Management in the Data Warehouse Era," *European Journal of Operations Research*, 1999, to appear.

CONFERENCE PRESENTATIONS:

Dolk, D.R., "Metrics Management," CSM98: 12th JISR-IIASA Workshop on Methodologies and Tools for Complex System Modeling and Integrated Policy Assessment, Vienna, Austria, September 1998.

Dolk, D.R., "Modeling in the Data Warehouse Era," IFIP 7.1 Working Group Conference, Vienna, Austria, September 1998.

Dolk, D.R., Murphy, M., and Thomas, G., "Metrics-Based, Spatial DSS for Manpower Readiness," 37th Army Operations Research Society Conference (AORS 37), Fort Lee, VA, October 1998.

PROJECT SUMMARIES IS

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Readiness, Manpower)

KEYWORDS: Manpower, Metrics, Spatial Decision Support System, Simulation, Data Warehouse

ANALYSIS AND EVALUATION OF A PROTOTYPE MAINTENANCE ADVISOR EXPERT SYSTEM FOR THE MK92 FIRE CONTROL SYSTEM

**Magdi N. Kamel, Associate Professor
Information Systems Academic Group**

Sponsor: Naval Surface Warfare Center-Port Hueneme Division

OBJECTIVE: The overall objective of this ongoing project is to develop a prototype maintenance advisor expert system for MK92 Fire Control System to enhance the ability of MK92 technicians to better determine, diagnose, and resolve problems within the system.

SUMMARY: The effort for the current reporting period involved completing the following tasks: 1) Analysis of the FCS MK92 Mod 2 MAES shipboard evaluation results of deployed modules; 2) Analysis and determination of the most effective method of porting the FCS MK92 Mod 2 MAES to the FCS MK92 Mod 1 and Mod 5 systems; and 3) Determination of the most suitable methodology for the development of future modules of the FCS MK92 Maintenance Advisor Expert System.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human-System Interfaces

KEYWORDS: Expert Systems, Knowledge Acquisition, Knowledge Representation

A COMPARATIVE STUDY OF DOCUMENT WORKFLOW MANAGER APPLICATIONS

**Magdi N. Kamel, Associate Professor
Information Systems Academic Group**

**Martin J. McCaffrey, Visiting Assistant Professor
Institute for Defense Education and Analysis**

Sponsor: Naval Surface Warfare Center-Port Hueneme Division

OBJECTIVE: The objective of this project is to perform a comparative analysis of Commercial-Off-The-Shelf (COTS) Workflow products to support the integration of Port Hueneme Division, (PHD) Naval Surface Warfare Center (NSWC) workflow requirements into the Integrated Data Management System (IDMS) centralized on-line Technical Data Management System. A related objective of the project is to look into methodologies for Business Process Improvement (BPI), workflow automation, and the relationship between the two.

SUMMARY: The effort for the current reporting period included completing the following tasks: 1) Conducting a detailed study of Business Process Improvement Methodologies; 2) Investigating workflow automation approaches and related technologies; and 3) Developing and refining a methodology for using workflow technology to improve current business processes and applying the methodology to improve the technical manual changes process at Port Hueneme Division of the Naval Surface Warfare Center.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Document Management, Business Process Analysis, Business Process Re-Engineering, Workflow Automation, Workflow Software

PROJECT SUMMARIES IS

MEASURING AND EVALUATING MAINTENANCE PROCESS USING RELIABILITY, RISK, AND TEST METRICS

Norman F. Schneidewind, Professor
Information Systems Academic Group

Sponsor: Naval Surface Warfare Center-Dahlgren Division

OBJECTIVE: Research was conducted on the NASA Space Shuttle flight software for the purpose of investigating a hypothesis of measuring and evaluating maintenance stability.

SUMMARY: Measuring and evaluating the stability of maintenance processes is important because of the recognized relationship between process quality and product quality. The focus was on the important quality factor *reliability*. A maintenance process can quickly become unstable because the very act of installing software changes the environment; pressures operate to modify the environment, the problem, and the technological solutions. Changes generated by users and the environment and the consequent need for adapting the software to the changes is unpredictable and cannot be accommodated without iteration. Programs must be adaptable to change and the resultant change process must be planned and controlled. Large programs are never completed, they just continue to evolve. In other words, with software, one is dealing with a moving target. Maintenance is performed continuously and the stability of the maintenance process has an effect on product reliability. Therefore, when the stability was analyzed of the NASA Shuttle software maintenance process, it was important to consider the reliability of the software that the process produces. Furthermore, a consideration was the efficiency of the test effort that is a part of the process and a determinate of reliability. Therefore, these factors were integrated into a unified model, which allowed measurement of the influence of maintenance actions and test effort on the reliability of the software. The hypothesis was that these metrics would exhibit trends and other characteristics over time that would be indicative of the stability of the process. The results indicate that this is the case.

PUBLICATIONS:

Schneidewind, Norman F., "Integration of Software Reliability Predictions, Risk Analysis, and Testing Strategies," *Proceedings of the Tenth Annual Software Technology Conference*, (CD-ROM), 24 pp., Salt Lake City, UT, 20 April 1998.

Schneidewind, Norman F., "Measuring and Evaluating the Development Process Using Reliability and Test Metrics," *Proceedings of the Tenth Annual Software Technology Conference*, (CD-ROM), 50 pp., Salt Lake City, UT, 21 April 1998.

Schneidewind, Norman F., "How to Evaluate Legacy System Maintenance," *IEEE Software*, Vol. 15, No. 4, pp. 34-42, July/August 1998.

Schneidewind, Norman F., "How to Evaluate Legacy System Maintenance," *Nikkei Computer Books*, pp. 232-240, Nikkei Business Publications, Inc., 2-1-1 Hirakawacho, Chiyoda-Ku, Tokyo 102 Japan, 1998.

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Schneidewind, Norman F., "An Integrated Process and Product Model," *Proceedings of the International Metrics Symposium*, pp. 224-234, Bethesda, MD, 20-21 November 1998.

PROJECT SUMMARIES IS

Schneidewind, Norman F., "Measuring and Evaluating Maintenance Process Using Reliability, Risk, and Test Metrics," *IEEE Transactions on Software Engineering*, to be published.

CONFERENCE PRESENTATIONS:

Schneidewind, Norman F., "Integration of Software Process and Product Measurement and Models," Stan Ackerman Institute Symposium on Software Technology, Eindhoven University of Technology, Eindhoven, The Netherlands, 6 November 1998.

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Schneidewind, Norman F., "Integration of Software Reliability Predictions, Risk Analysis, and Testing Strategies," Tenth Annual Software Technology Conference, Salt Lake City, UT, 20 April 1998.

Schneidewind, Norman F., "Measuring and Evaluating the Development Process Using Reliability and Test Metrics," Tenth Annual Software Technology Conference, Salt Lake City, UT, 21 April 1998.

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Schneidewind, Norman F., "An Integrated Process and Product Model," International Metrics Symposium, Bethesda, MD, 20-21 November 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Metrics, Software Maintenance, Modeling

CONSIDERING RELIABILITY RISK IN THE SOFTWARE MAINTENANCE

PROCESS: SPACE SHUTTLE EXAMPLE

Norman F. Schneidewind, Professor

Information Systems Academic Group

Sponsor: Naval Surface Warfare Center-Dahlgren Division

OBJECTIVE: Measure and evaluate the Software Maintenance Process and Metrics-Based Software Quality Control.

SUMMARY: To gain insight about the interaction of the maintenance process with product metrics like reliability, trends were analyzed in these metrics. Two types of trends were analyzed: across releases and within a release. When analyzing trends, it was noted whether an increasing or decreasing trend was favorable. For example, an increasing trend in Time to Next Failure and a decreasing trend in Failures per KLOC would be favorable. Conversely, a decreasing trend in Time to Next Failure and an increasing trend in Failures per KLOC would be unfavorable. A favorable trend is indicative of maintenance stability if the functionality of the software has increased with time across releases and within releases. When trends in these metrics over time are favorable (e.g., increasing reliability), it could be concluded that the maintenance process is stable with respect to the software metric (reliability). Conversely, when the trends are unfavorable (e.g., decreasing reliability), it could be concluded that process is unstable. A Change Metric (CM) was developed. The CM is a quantity from 0 to 1. A positive value indicates stability; a negative value indicates instability. The numeric value of CM indicates the degree of stability or instability. CM only pertains to stability or instability with respect to the particular metric that has been evaluated (e.g., Failures/KLOC). The evaluation of stability should be made with respect to a set of metrics and not a single metric. An average of the values of CM across releases could also be computed to obtain an overall metric of stability.

PROJECT SUMMARIES IS

PUBLICATIONS:

Nikora, Allen P., Schneidewind, Norman F., and Munson, John C., "TV&V Issues in Achieving High Reliability and Safety in Critical Control Software, Final Report," "Volume 1 - Measuring and Evaluating the Software Maintenance Process and Metrics-Based Software Quality Control," "Volume 2 - Measuring Defect Insertion Rates and Risk of Exposure to Residual Defects in Evolving Software Systems," and "Volume 3 - Appendices," Jet Propulsion Laboratory, National Aeronautics and Space Administration, Pasadena, CA, 19 January 1998.

Schneidewind, Norman F., "How I Watched in Pain as IBM Outsmarted UNIVAC," *In the Beginning: Recollections of Software Pioneers*, pp. 54-61, IEEE Computer Society Press, Robert L. Glass, (ed.), 1998.

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Schneidewind, Norman F., "How Can Changes in the Functionality of Maintained Systems be Measured?" *Proceedings of the Third Annual Workshop on Empirical Studies of Software Maintenance*, pp. 27-28, WESS '98, Bethesda, MD, 16 November 1998.

Schneidewind, Norman F., "Methods for Assessing COTS Reliability, Maintainability, and Availability," *Proceedings of the International Conference on Software Maintenance*, pp. 224-225, Bethesda, MD, 16-20 November 1998.

CONFERENCE PRESENTATIONS:

Schneidewind, Norman F., "Considering Risk in Software Reliability Predictions: A Space Shuttle Example," NASA - West Virginia University Workshop on Risk Management, Farmington, PA, 26 October 1998.

Schneidewind, Norman F., "State of the Art Presentation 2: Software Reliability Modeling for Client Server Systems," Fourth IEEE International Conference on Engineering of Complex Computer Systems, Monterey, CA, 13 August 1998.

Schneidewind, Norman F., "Have We Forgotten a Few Things in the Euphoria Over COTS?" International Workshops on Critical-Functions Considerations for ISO/IEC 15288 - System Life Cycle Processes: Panel on Off-the-Shelf Items, Monterey, CA, 11 August 1998.

Schneidewind, Norman F., "Everything You Wanted to Know About SRE But Didn't Know Who to Ask," International Symposium on Software Reliability Engineering, Paderborn, Germany, 6 November 1998.

Schneidewind, Norman F., "How Can Changes in the Functionality of Maintained Systems be Measured?" Third Annual Workshop on Empirical Studies of Software Maintenance, WESS '98, Bethesda, MD, 16 November 1998.

Schneidewind, Norman F., "Methods for Assessing COTS Reliability, Maintainability, and Availability," International Conference on Software Maintenance, Bethesda, MD, 16-20 November 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Metrics, Software Reliability, Software Risk

PROJECT SUMMARIES IS

DEVELOPMENT OF NEW SOFTWARE DEPENDABILITY STANDARDS

Norman F. Schneidewind, Professor

Information Systems Academic Group

Sponsor: IEEE Software Engineering Standards Subcommittee

OBJECTIVE: To recommend appropriate reliability, maintainability, and availability technologies to include in new and revised software engineering standards.

SUMMARY: In general, existing software reliability standards do not address the characteristics of distributed systems, including client-server systems. This is an amazing situation given the importance of distributed systems in contemporary society. The reason for this situation is the rapid technological development of distributed systems and networks, most notably the explosive growth of the Internet. This rapid growth has made it difficult for the software reliability and standards development communities to respond to the challenge of the new technology. However, to address this deficiency, the software engineering community of the Institute of Electrical and Electronic Engineers will develop a new standard, which will include software reliability, maintainability, and availability for distributed systems.

PUBLICATIONS:

Schneidewind, Norman F., et al., "Roundtable: Weighing in on Standards," *IEEE Software*, Vol. 15, No. 6, pp. 92-102, November/December 1998.

Schneidewind, Norman F., "Issues in the Next Generation of Dependability Standards," *Proceedings of the International Symposium on Software Reliability Engineering*, pp. 101-102, Paderborn, Germany, 4-7 November 1998.

Schneidewind, Norman F., "IEEE Standard for a Software Quality Metrics Methodology: Revision," Celia Modell, (ed.), IEEE Standards Office, December 1998.

CONFERENCE PRESENTATION:

Schneidewind, Norman F., "Issues in the Next Generation of Dependability Standards," International Symposium on Software Reliability Engineering, Paderborn, Germany, 4-7 November 1998.

THESIS DIRECTED:

Flatau, Richard P., Jr., "Operationalization of Information Technology for the 21st Century (IT-21): The Flight Scheduling Function in Patrol Squadron 40 as a Case Study," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Standards, Software Dependability, Software Metrics

DECISION SUPPORT FOR VIRTUAL TEAMS: DESIGN PRINCIPLES

Kishore Sengupta, Associate Professor

Information Systems Academic Group

Sponsor: Naval Postgraduate School

OBJECTIVE: The objectives of this project were to: (1) propose mechanisms for supporting virtual teams with respect to the problems of conflict and the retention/use of process knowledge; (2) illustrate the requirements for creating such mechanisms through a prototype system; and (3) discuss the implications of these requirements for implementation as well as research in conflict management, process knowledge, and computer-supported collaborative work.

PROJECT SUMMARIES IS

SUMMARY: Virtual teams were used extensively in contemporary organizational settings to perform a variety of tasks. While virtual teams offered several advantages to organizations, their use in tasks such as product design created difficulties in managing conflicts and in the retention and uses of "process knowledge."

PUBLICATIONS:

Sengupta, K. and Zhao, L., "Improving the Communicational Effectiveness of Virtual Organizations Through Workflow Automation," *International Journal of Electronic Commerce*, Vol. 3, pp. 49-69, 1998.

Sengupta, K. and Zhao, L., "An Empirically Grounded Approach," *Proceedings of the Thirty-First Annual Conference of the Hawaii International Conference on System Sciences*, Vol. IV, J. Nunamaker, (ed.), IEEE Computer Society Press, 1998.

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CONFERENCE PRESENTATION:

Sengupta, K., "The Representation and Use of Process Knowledge in the Design of Information Systems," AIS '98, Baltimore, MD, August 1998.

DoD KEY TECHNOLOGY AREA: Other (Virtual Teams, Decision Support Systems, Software)

KEYWORDS: Virtual Teams, Decision Support Systems, Software

PUBLICATIONS/PRESENTATIONS IS

JOURNAL PAPERS

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Schneidewind, Norman F., "Empirical Studies of Software Maintenance: A Report from WESS '97, Working Group 1: Defect Detection and Analysis," *Empirical Software Engineering*, Vol. 3, No. 3, pp. 300-301, Kluwer Academic Publishers, September 1998.

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Ceruti, M.G. and Kamel, M.N., "Heuristics-Based Algorithm for Identifying and Resolving Semantic Heterogeneity in Command and Control Federated Database Systems," *Proceedings of the IEEE Knowledge and Data Engineering Exchange Workshop*, pp. 17-26, Taipei, Taiwan, November 1998.

Kamel, M.N., "Migrating Legacy Systems and Databases," *Proceedings of the Federal Database Colloquium DBASE '98*, pp. 35-39, San Diego, CA, September 1998.

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Dolk, D.R., "Metrics Management," CSM98: 12th JISR-IIASA Workshop on Methodologies and Tools for Complex System Modeling and Integrated Policy Assessment, Vienna, Austria, September 1998.

Dolk, D.R., "Modeling in the Data Warehouse Era," IFIP 7.1 Working Group Conference, Vienna, Austria, September 1998.

Dolk, D.R., Murphy, M., and Thomas, G., "Metrics-Based, Spatial DSS for Manpower Readiness," 37th Army Operations Research Society Conference (AORS 37), Fort Lee, VA, October 1998.

Kamel, M.N., "Research Proposal Development," Tenth Annual Kasr El-Aini Medical Congress, Cairo, Egypt, March 1998.

Kamel, M.N., "The Internet from Hypertext to Distributed Objects," Fourth Annual International Internet Conference CAINET'98, Cairo, Egypt, March 1998.

Kamel, M.N., "Information Technology and Intellectual Property Rights," World Intellectual Property Rights Organization Seminar, Cairo, Egypt, June 1998.

Schneidewind, Norman F., "Integration of Software Process and Product Measurement and Models," Stan Ackerman Institute Symposium on Software Technology, Eindhoven University of Technology, Eindhoven, The Netherlands, 6 November 1998.

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Sengupta, K., "The Representation and Use of Process Knowledge in the Design of Information Systems," AIS '98, Baltimore, MD, August 1998.

CONTRIBUTIONS TO BOOKS

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PUBLICATIONS/PRESENTATIONS IS

TECHNICAL REPORTS

Nikora, Allen P., Schneidewind, Norman F., and Munson, John C., "TV&V Issues in Achieving High Reliability and Safety in Critical Control Software, Final Report," "Volume 1 - Measuring and Evaluating the Software Maintenance Process and Metrics-Based Software Quality Control," "Volume 2 - Measuring Defect Insertion Rates and Risk of Exposure to Residual Defects in Evolving Software Systems," and "Volume 3 - Appendices," Jet Propulsion Laboratory, National Aeronautics and Space Administration, Pasadena, CA, 19 January 1998.

Schneidewind, Norman F., "IEEE Standard for a Software Quality Metrics Methodology: Revision," Celia Modell, (ed.), IEEE Standards Office, December 1998.

OTHER

Bhargava, H., RDdss: Decision Support System Software for Recruit Distribution, (delivered and installed at USMC Manpower and Reserve Affairs).

Bhargava, H., EAM-NPS: Optimization Model and Solver Software for Enlisted Assignment.

1998 THESIS ABSTRACTS IS

INTRANET PROTOTYPE FOR THE UNITED STATES COAST GUARD ELECTRONIC SYSTEMS SUPPORT UNIT ALAMEDA

Ralph L. Benhart-Lieutenant, United States Coast Guard

B.S., Wayne State University, 1992

Master of Science in Information Technology Management-September 1998
and

Dean J. Dardis-Lieutenant, United States Coast Guard

B.S., Weber State University, 1991

Master of Science in Information Technology Management-September 1998

Advisors: Suresh Sridhar, Information Systems Academic Group

Carl Jones, Information Systems Academic Group

The objective of this thesis is to explore uses of Internet technologies and business model enhancements for Electronic Systems Support Unit (ESU) Alameda, a small Coast Guard command. To accomplish this task, this thesis will introduce the concept of Intranet technology, portray the efforts required to create an Intranet, and then discuss the benefits associated with Intranet use.

The thesis introduces two popular design methodologies, analyzes the advantages and disadvantages of each, and determines the best Intranet design methodology for this project by analyzing the needs and abilities of the organization. In addition, it describes the gathering of system and user requirements, data types, processes performed, business model evaluations, and conceptual Intranet development.

The work comprised within this thesis will enable coding and implementation of the Intranet by another thesis team working jointly on this project. While this thesis covers details of analysis and specification development, the thesis of the other team will continue discussion by addressing software coding, security, and maintenance.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Intranet, ESU, Rapid Prototyping, Coast Guard, Computer, Web-Based Application, Specification, Business Model, Data Flow Diagrams, Processes, Electronic Systems Support Unit Alameda

RE-ENGINEERING THE UNITED STATES MARINE CORPS SPECIAL EDUCATION PROGRAM (SEP)

Arthur W. Bornschein-Captain, United States Marine Corps

B.S., Cornell University, 1989

Masters of Science in Information Technology Management-March 1998
and

Michael Jernigan-Captain, United States Marine Corps

B.S., Auburn University, 1992

Masters of Science in Information Technology Management-March 1998

Advisors: Hemant K. Bhargava, Information Sciences Academic Group

Suresh Sridhar, Information Sciences Academic Group

LtCol Timothy Phillips, U.S. Marine Corps Representative

Within the United States Marine Corps, there exist billets (jobs) that require specialized graduate education. Department of Defense agencies submit requests to add billets to their organizational structure. Marine Corps Orders require for every billet added another must be removed elsewhere to balance manpower requirements. Additionally, continuing validation of the billets is required to ensure compliance with Secretary of Defense criteria. Problems in the key function, billet validation, include inflexible, inefficient, and ineffective processes, and nebulous validation criteria.

We address these problems by developing a centralized decision support system to be used in a distributed collaborative setting. The objectives of the Special Education Program (SEP) Billet Validation System are to allow SEP billet holders and commands to evaluate and justify existing SEP billets, to assist Military Occupational Specialty Sponsors in identifying manpower reductions, and to validate the graduate education requirement for existing SEP billets. Methods from Multi-

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Criteria Decision-Making (MCDM) specifically Multi-Attribute Utility Theory (MAUT) and the Analytical Hierarchy Process (AHP) are used to formalize Secretary of Defense requirements and quantify relative ratings of billets. The system employs a Web Browser front-end application to allow the administrative review process to be performed in a parallel manner.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel and Training, Modeling and Simulation

KEYWORDS: Graduate Education, U.S. Marine Corps, Decision Support, Manpower, Web Browser, Utility Theory

FRAMEWORK FOR A LINK LAYER PACKET FILTERING SECURITY PROTOCOL

Gregorio G. Darroca-Civilian

B.S., United States Naval Academy, 1979

Master of Science in Information Technology Management-September 1998

Advisors: Geoffrey Xie, Department of Computer Science

Cynthia Irvine, Department of Computer Science

Rex Buddenberg, Information Systems Academic Group

Transport Layer (OSI Layer 3) switching and routing provides routing flexibility but not high throughput. Link layer (OSI Layer 2) switching provides high throughput but not the routing flexibility needed to manage topology change and load fluctuations in the network. Neither Layer 3 routing nor Layer 2 switching protocols were originally designed to support confidentiality and integrity of data, and authentication of participants. Proposals to integrate security may have positive results for data confidentiality, integrity and authentication, but often result in additional overhead, increased transmission latency, and decreased throughput. An added difficulty is reconciling standards and protocols when integrating heterogeneous routing networks with homogenous switching networks while minimizing impact on throughput.

This thesis examined current Internet extensions and architectures as well as IP security services and Layer 2 switching in IP-based networks. Requirements for a framework for a proposed security protocol include: Link Layer switching and routing; independence of particular communication protocols and standards; IP packet filtering and routing according to predetermined security policies and with no significant impact on throughput; and continued routing flexibility of IP. This security protocol, called Link Layer (Link Layer Packet Filtering (LLPF)), filters packets at the Link Layer, and boasts two innovations: use of an authentication trailer and multiple cryptographic keys with short cryptoperiods.

DoD KEY TECHNOLOGY AREA: Other (Computer Network Security)

KEYWORDS: Network Security, Asynchronous Transmission Mode (ATM), Internetworking, Protocol

1998 THESIS ABSTRACTS IS

DECISION SUPPORT FOR RECONNAISSANCE USING INTELLIGENT SOFTWARE AGENTS

Marcia R. Edmiston-Lieutenant, United States Navy

B.A., University of Kansas, 1989

Master of Science in Information Technology Management-March 1998

and

Darrell R. Gregg, Jr-Captain, United States Army

B.S., Northeast Missouri State University, 1989

Master of Science in Information Technology Management-March 1998

and

David G. Wirth-Lieutenant, United States Navy

B.S., Pennsylvania State University, 1990

Master of Science in Information Technology Management-March 1998

Advisors: Tung X. Bui, Department of Systems Management

Carl R. Jones, Information Sciences Academic Group

Suresh Sridhar, Information Sciences Academic Group

Research in reconnaissance traditionally focuses on data detection and discrimination methods. Less emphasis is placed on transforming the collected data into useful information and presenting it to key command and control nodes in time for operational use. Information not presented in a timely manner is excluded from the decision process. This thesis proposes a conceptual model of intelligent software agents to support the human decision process and reconnaissance related tasks. The Mobile Agent Reconnaissance Kit (MARK) suggests a hierarchy of software agents to facilitate data integration and coordination in a network-centric multisensor environment. The model uses static and mobile agents to collect data from dispersed, heterogeneous data sources, process and fuse the data, and present the resultant information to the user in an HTML file. The authors explore applications of MARK in terms of the Military Intelligence Cycle, the Joint Director of Laboratories (JDL) Technical Panel for C3I Data Fusion Model, and the Joint Operations Planning and Evaluation System (JOPES) Crisis Action Procedures.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Human Systems Interface

KEYWORDS: Software Agent, Intelligent Software Agent, Mobile Software Agent, Reconnaissance, Decision Support

OPERATIONALIZATION OF INFORMATION TECHNOLOGY FOR THE 21ST CENTURY (IT-21): THE FLIGHT SCHEDULING FUNCTION IN PATROL SQUADRON 40 AS A CASE STUDY

Richard P. Flatau, Jr-Major, United States Marine Corps

B.S., George Mason University, 1983

Master of Science in Information Technology Management-September 1998

Advisors: Norman F. Schneidewind, Information Systems Academic Group

Douglas E. Brinkley, Department of Systems Management

In the past several years, greater exploitation of information technology to increase leverage of information has become a central focus in the military. This focus is reflected in a number of strategic vision documents. Two significant examples are "Joint Vision 2010" signed in 1996 by the Chairman of the Joint Chiefs of Staff and the 1997 Quadrennial Defense Review Report. Achieving and using information superiority is seen as essential to future military success. This has led to the emergence of a new warfare paradigm: network-centric warfare.

Towards this end, the Navy's service-wide IT improvement initiative is Information Technology for the 21st Century (IT-21). IT-21 establishes a standard for IT capability to be achieved throughout the Navy within which Navy units can shape their IT improvements.

This study explores a requirements-approach for planning improvement of IT through IT-21. Specifically, it focuses on a single function of one squadron: flight scheduling in Patrol Squadron 40. This study addresses how to establish

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information requirements, assess current IT performance, and formulate specifications by which to drive planning for IT improvement. It concludes by mapping IT-21 components to requirements to provide VP-40 with a plan for improving its flight scheduling process through IT-21.

DoD KEY TECHNOLOGY AREA: Other (Information Technology Systems Analysis and Design)

KEYWORDS: IT-21, Flight Scheduling, Information Technology, Systems Analysis and Design

A FUNCTIONAL INTRANET FOR THE UNITED STATES COAST GUARD UNIT

Robert T. Hannah-Lieutenant, United States Coast Guard

B.S., United States Coast Guard Academy, 1991

Master of Science in Information Technology Management-September 1998

Advisors: Suresh Sridhar, Information Systems Academic Group

Carl Jones, Information Systems Academic Group

This thesis describes the complete development process of a functional Intranet for an operational United States Coast Guard (USCG) Electronic Support Unit (ESU) in Alameda, California. The final product is suitable for immediate use. It may also be used as a prototype for future Intranet development efforts.

The methodology used to develop a finished, working product provides the core subject matter for this thesis. The discussion concentrates on why certain applications were developed and what business benefits they provide.

The Intranet was developed in seven unique stages of the Waterfall Model of information systems design. The Waterfall Model traces a systems development lifecycle from planning, to logical design, through physical design, and finally ends with the implementation process. Each stage of the development model is addressed in this thesis.

Intranet technology provides a radical new means of communicating throughout an organization, which has the potential to change the organization. Elaboration on both the social and technical aspects of introducing an information systems change to the ESU is included.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Intranet, Information Systems Design, HTML, Active Server Pages, Web Enabled Database, Internet, World Wide Web, Web Authoring, Waterfall Model, Rapid Prototyping, Coast Guard, ESU Alameda

DESIGN CONSIDERATIONS TO BE ADDRESSED WHEN DEVELOPING WEB BASED APPLICATIONS FOR SENIOR MANAGERS

David W. Hardy-Lieutenant, United States Navy

B.S., University of Georgia, 1991

Master of Science in Information Technology Management-September 1998

Advisor: Barry Frew, Information Systems Academic Group

Second Reader: Rudy Darken, Department of Computer Science

This thesis develops guidelines for building Web sites that are useful to senior managers in two ways. First, these managers can obtain information from or pass information to a site in order to accomplish tasks more effectively and efficiently. Secondly, the senior manager must be able to go to a site and use that site without being required to undergo instruction or read manuals before using the site. Web technology is in place to assist these managers in performing at a higher level. Methodologies used in this thesis combine a study using sample web sites, based on the Center for Executive Education Web Site, two surveys, database connectivity, and usability design practices to aid in Internet or intranet based applications. This document contains results from surveys of senior managers which are evaluated to select a suitable methodology for designing Web sites specifically for this subset of users.

1998 THESIS ABSTRACTS IS

DoD KEY TECHNOLOGY AREA: Other (Interface Design)

KEYWORDS: Usability, ODBC, Interface Design, Senior Management, Senior Managers, Internet, Intranet, Web Based Application Interface

AN AGENT-BASED APPROACH TO ANALYZING INFORMATION AND COORDINATION IN COMBAT

Richard B. Hencke-Lieutenant, United States Navy
B.S., California State Polytechnic University, Pomona, 1990
Master of Science in Systems Engineering-September 1998
Advisors: Donald P. Gaver, Department of Operations Research
Carl R. Jones, Information Systems Academic Group

The quality and quantity of information flows is a critical factor in the command and control of forces in battle. Many current simulations do not adequately show the interactive effects of information on the battlefield. Agent-based simulation is a promising technique that can provide insight into these effects.

The purpose of this thesis is to develop an agent-based simulation to analyze the relationship between information and command structure. (SinBaD) Simulation of Information in Battlefield Decisions is the agent-based simulation developed specifically for this thesis. Although SinBaD is only an abstract model of combat, it is believed that this approach can provide much insight into the mechanisms that affect the effectiveness of information in battle.

Several combat scenarios are simulated using different control rules. These simulations suggest that there exists scenarios where information is essential to mission success and some cases where its role is less instrumental or even detrimental. Other insights generated from this research suggest that agent-based simulation may help define metrics useful in aiding decision-makers during the planning and execution of a large and complex campaign.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Agent-Based Simulation, Complexity Theory, Complex Adaptive Systems

SOFTWARE AGENTS AND THE DEFENSE INFORMATION INFRASTRUCTURE: RE-ENGINEERING THE ACQUISITION PROCESS

Jerome Hudson-Major, United States Army
B.S., Prairie View A&M University, 1984
Master of Science in Management-September 1998
Advisors: Mark E. Nissen, Department of Systems Management
Tung X. Bui, Information Systems Academic Group

Process innovation within the Department of Defense (DoD) procurement system ultimately translates into flexibility, combat effectiveness, and technological advantage on the modern battlefield. A critical enabler of process innovation is the effective use of advanced information technology (IT) products, such as software agents. Software agent-based systems are used as an IT enabler for redesigning processes within the Defense Information Infrastructure (DII) Acquisition system. The Simplified Acquisition Procedures (SAP), a key element of acquisition reform, are used as the focus of our redesign efforts. To accomplish this task, the process is represented using a traditional process-flow model, Use Case analysis to integrate the DII macro-process view and the agent technology micro-view, and using a heuristic measure of process complexity to identify processes suitable for machine versus human performance. By exploiting the inherent strengths of both software and human agents, productivity is enhanced by freeing human agents from routine tasks and enables the refocusing of human resources to high value acquisitions. The result is an agent-based redesign of SAP processes where human agents and software agents share in the responsibilities for process execution.

1998 THESIS ABSTRACTS IS

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Agents, Acquisition Reform, Process Innovation, Defense Information Infrastructure

RE-ENGINEERING THE UNITED STATES MARINE CORPS' ENLISTED ASSIGNMENT MODEL (EAM)

**Gary D. Koch Jr.-Major, United States Marine Corps
B.S., The Citadel, 1986**

**Master of Science in Information Technology Management-June 1998
Advisors: Hemant K. Bhargava, Information Sciences Academic Group
Suresh Sridhar, Information Sciences Academic Group**

In a time of downsizing and budgetary constraints the Manpower division of Headquarters, the United States Marine Corps, accomplishes its mission "to put the right Marine in the right place at the right time with the right skills and quality of life" in a variety of ways. Currently, one of the processes that assist the Marine Enlisted Assignments branch is the Enlisted Assignment Model. The current system is not producing the results that are needed and the current managers do not trust the output. This thesis proposes changes to the EAM user interface, data access, and data storage capabilities to enable the Marine Corps to use the latest information technology to more closely mirror the vision as stated above. With the use of Business Process Re-engineering, Process Modeling, and Database Design a prototype is developed to address areas of the current system that can be changed. By using these methods to ensure an appropriate interface with optimization techniques, a complete Decision Support System for manpower assignments can be realized. These changes will empower managers to effectively and efficiently manage, not just monitor manpower readiness in order to meet the challenges of the 21st century.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel Management and Assignment, Database Management Systems

KEYWORDS: U.S.M.C., Databases, Manpower Assignment, Models, Decision Support Systems, Graphical User Interface

VRML TERRAIN MODELING FOR THE MONTEREY BAY NATIONAL MARINE SANCTUARY (MBNMS)

**R. Greg Leaver-Lieutenant, United States Navy
B.S., Oklahoma State University, 1987**

**Master of Science in Information Technology Management-September 1998
Advisor: Don Brutzman, Undersea Warfare Academic Group
Rex Buddenberg, Information Systems Academic Group**

This thesis develops an online model of the topographic terrain of Monterey Bay National Marine Sanctuary (MBNMS) seafloor. Written in the Virtual Reality Modeling Language (VRML), the model is an interactive 3D application composed of hundreds of topographic tiles linked together to form a mosaic of the bay. Low-resolution tiles are traded for higher resolution tiles as the viewer gets closer to the terrain.

Important contributions include a naming convention for autogeneration of interlinked files, test usage of proposed metadata conventions linking VRML and the eXtensible Markup Language (XML), demonstrated use of the GeoVRML Working Groups proposed QuadLOD node, and a preliminary 3D navigation icon for terrain interrogation and wayfinding. Terrain data was produced from registered, smoothed and subsampled bathymetric sonarscan results. Because the model is geo-referenced with the Universal Transverse Mercator (UTM) coordinate system, a user can easily add scientific content or data to a selected location of the MBNMS in a manner analogous to adding 2D content to an HTML page. Thus, the user can place 3D content anywhere in the MBNMS in geographic context merely by specifying the geographic coordinates and depth of the content in standard VRML syntax.

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Future work includes improvement of metadata interoperability, navigation icon user testing, and autogeneration of image-based texture tiles for scientific visualization.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Environmental Quality, Human Systems Interface, Sensors, Modeling and Simulation

KEYWORDS: World Wide Web, Virtual Reality Modeling Language (VRML), Large-Scale Virtual Environments (LSVEs), Monterey Bay, 3D Graphics Modeling

INTRANET-BASED DECISION SUPPORT FOR THE MARINE AIR GROUND TASK FORCE AVIATION COMBAT ELEMENT

Malcolm LeMay-Major, United States Marine Corps

B.S., United States Naval Academy, 1983

M.A.I.S., Old Dominion University, 1992

Master of Science in Information Technology Management-September 1998

Advisors: Suresh Sridhar, Information Systems Academic Group

Barry Frew, Information Systems Academic Group

Information technology can be an effective force multiplier for the Air Combat Element (ACE) of the Marine Air Ground Task Force (MAGTF). Through the use of Intranet-based decision support, internet technology can be leveraged to improve the decision support and information processes of the ACE. This thesis reviews the objectives of Intranet-based decision support and provides a methodology to follow for implementing Intranet-based decision support for the ACE. The methodology combines systems development life cycle (SDLC) practices, command and control theory, an organizational analysis of the ACE and prototyping to achieve Intranet-based decision support. The results from a process analysis are evaluated to select suitable processes for migration to Intranet-based decision support. Prototype development involves coding approximately 100 software files in Cold Fusion. As part of the prototyping process, comments from fleet-based Marines are collected and incorporated in the prototype when possible. The methodology developed for this project could be used for other MAGTF related Intranet-based decision support systems.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Intranet, Marine Air Ground Task Force (MAGTF), Air Combat Element (ACE), Intranet-Based Decision Support

INTRANET FOR THE SYSTEMS MANAGEMENT DEPARTMENT

Robert H. Lunn-Major, United States Army

B.S., Texas Tech University, 1983

Master of Science in Information Technology Management-March 1998
and

Edward D. Loewen-Captain, United States Army

B.B.A., Oklahoma University, 1987

Master of Science in Information Technology Management-September 1997

Advisor: Suresh Sridhar, Information Sciences Academic Group

Second Reader: Hemant Bhargava, Information Sciences Academic Group

The objective of this thesis is to describe in detail the reasoning and development of an Intranet-based decision support system. This thesis is intended to show how World Wide Web technologies can be used to develop a prototype Intranet that can provide access to information for faculty, students, and staff members via a World Wide Web browser. It provides more open communication in the Department of Systems Management, quicker and more consistent information flows (service) to the faculty and staff, and reduced time spent on the handling of repetitive and often simple information exchanges. The

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decision support function is supported by a database which is an information clearinghouse, providing all personnel with 24-hour access. Personnel are empowered by information availability and are likely to be more proactive. A prototype has been developed to demonstrate the concept and to demonstrate the validity of rapid prototyping as a means of validating the effectiveness of the modified Intranet development methodology. The prototype is located at (<http://131.120.41.236>).

DoDKEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Intranet, Decision Support System, World Wide Web

**PROCESS INNOVATION: ANALYSIS AND REDESIGN OF THE CALIFORNIA ARMY
NATIONAL GUARD STATE EMERGENCY MOBILIZATION PROCESS**

Patrick F. McGuire-Captain, United States Marine Corps

B.S., Pennsylvania State University, 1992

Master of Science in Information Technology Management-September 1998

and

David A. White-Lieutenant, United States Navy

B.S., Jacksonville University, 1990

Master of Science in Information Technology Management-September 1998

and

Andrew J. Palan-Captain, United States Marine Corps

B.A., University of Missouri-Columbia, 1991

Master of Science in Information Technology Management-December 1998

Advisors: Suresh Sridhar, Information Systems Academic Group

Mark E. Nissen, Department of Systems Management

Process innovation can empower an organization to realize orders of magnitude improvement in its key business processes. Through process redesign, information technology can be used as an enabler to support effective, efficient, and cross-functional business processes. The area of research for this thesis is the analysis and redesign of the State Emergency Mobilization Process (SEMP) of the California Army National Guard. This is accomplished through a detailed study of the State Emergency Mobilization Process with an emphasis of the key business processes of the California Army National Guard. The baseline process will be measured and diagnosed for inhibiting pathologies, and redesigned processes will be proposed based on benchmarking best practices of other organizations and by utilizing Process Innovation best practices. Critical process enablers such as people, culture and technology will be examined and applied to redesign alternatives. Once completed, the best redesigned business process will be recommended and an implementation plan drafted to integrate with the CA-ARNG Strategic Information Systems Plan.

DoD KEY TECHNOLOGY AREA: Other (Process Innovation)

KEYWORDS: California Army National Guard, Benchmarking, Reengineering, CA-ARNG, Change Management

1998 THESIS ABSTRACTS IS

REMOTE NETWORK ADMINISTRATION OF THE SEANET COMMUNICATION NODE SYSTEM

Don C. Murray-Lieutenant, United States Navy

B.S., University of Oklahoma, 1991

**Master of Science in Information Technology Management-September 1998
and**

Christopher L. Pratt-Lieutenant, United States Navy

B.S., Virginia Military Institute, 1990

Master of Science in Information Technology Management-September 1998

Advisor: Rex Buddenberg, Information Systems Academic Group

Second Reader: Don Brutzman, Undersea Warfare Academic Group

Maritime data communications are expensive and of limited capacity. Currently there is no established infrastructure to support Internet connectivity for sea-going vessels. The SeaNet program is investigating maritime networking solutions. One aspect of the SeaNet program is promoting remote network management. Remote network management will provide the maritime research community with a flexible and cost-effective tool for monitoring sea based assets. The objective of this thesis is to investigate remote network management over a satellite connection in support of the SeaNet programs goals.

To research the potential for remote network management, the Naval Postgraduate School has developed its own SeaNet laboratory. This laboratory simulates both the shipboard and shore-based infrastructure of the SeaNet program and conducts remote network management on these components. This thesis discusses the SeaNet program, network management concepts, the NPS SeaNet laboratory, research findings, and recommendations for future research. Remote Network Management of the SeaNet Control Node system is possible, however, continued research in this area is needed.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Network Management, Internet-to-Sea, SeaNet

DETERMINING AND APPLYING TELEMEDICINE MEASURES OF EFFECTIVENESS WITHIN THE U.S. NAVY

Doris J. Nedved-Lieutenant, United States Navy

B.S., South Dakota State University, 1991

Master of Science in Information Technology Management-September 1998

Advisors: Barry Frew, Information Systems Academic Group

Tung Bui, Information Systems Academic Group

Telemedicine is a system of healthcare delivery tools which uses telecommunications consultations as an alternative to transportation of the patient. There are no conclusive studies to prove or disprove the use of telemedicine and it is often implemented with little basis for measuring its effectiveness. Recent initiatives have been driven by advances in technology and pressure by upper management to reduce the cost of health care, but not from local needs assessments. This thesis provides a methodology to collect data used in supporting measures of effectiveness. The methodology is developed through a review of strategic goals, an assesment of potential measures of effectiveness, and the use of a model for data collection. It is applied at a Navy medical treatment facility recently installing telemedicine equipment.

DoD KEY TECHNOLOGY AREAS: Other (Information Systems and Technology, Medical and Biomedical)

KEYWORDS: Measures of Effectiveness, Telemedicine

1998 THESIS ABSTRACTS IS

GARRISON BASED INTRANET PROTOTYPE FOR THE 40TH INFANTRY DIVISION (MECHANIZED)

Thomas M. Olson-Major, United States Army

B.S., South Dakota State University, 1983

**Master of Science in Information Technology Management-March 1998
and**

Nelson T. Heckroth-Major, United States Marine Corps

B.A., Oregon State University, 1985

Master of Science in Information Technology Management-September 1997

Advisor: Suresh Sridhar, Information Sciences Academic Group

Second Reader: Tung Bui, Information Sciences Academic Group

This thesis introduces the concept of an Intranet, chronicles the efforts required to create and deliver an Intranet, and provides a discussion of advantages and disadvantages of using an Intranet. It demonstrates that an Intranet can be a useful mechanism to solve problems related to information control and distribution for the reserve component of the 40th Infantry Division (Mechanized).

The thesis contains a detailed description of the rapid prototyping process model, as well as the modifications required to adapt the process for Intranet development. Further, it describes the gathering of system requirements using the results of several structured walk-throughs. It also describes, in detail, the development efforts to address each of the requirements identified.

The prototype developed as part of this thesis demonstrates several key aspects of Intranet development and deployment. For example, it incorporates webpage development using commercial-off-the-shelf products common to the division, and the development of interactive functions with spreadsheet and database programs. This thesis also addresses issues such as security and content control which are crucial for Intranet deployment.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Other (Intranet/Network Design)

KEYWORDS: Intranet Design, Garrison, Ground Unit

A NAVAL RESERVE DATABASE APPLICATION AND FUTURE NETWORK SOLUTIONS

Bruce M. Patrou-Commander, United States Naval Reserve

B.S., University of West Florida, 1981

Master of Science in Information Technology Management-June 1998

Advisors: Suresh Sridhar, Information Sciences Academic Group

William R. Gates, Department of Systems Management

This thesis develops a Naval Reserve squadron database management system prototype and provides recommendations on future network solutions. The development centers on a Strike Fighter Squadron 203 (VFA-203), located in Atlanta, Georgia.

This project focuses on an application, which will support those current critical administrative systems that are not electronically automated or do not reside in a distributed computing environment. Emphasis is on utilizing current hardware and software while minimizing costs, training and organizational change associated with new information systems. Database scalability using Access 97 and IT 21 compliance are important features of this system.

A small local area network (LAN) option in a Peer-to-Peer configuration is discussed as a means to increase system efficiency by providing distributed access to this application. Future client/server network architecture capable of far greater scalability, network sharing and security will be recommended for further increases in system effectiveness.

1998 THESIS ABSTRACTS IS

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Database Management System, DBMS, Access 97 Software, Local Area Network, LAN

**THE DEVELOPMENT OF A LITTORAL REGION AREA COMMUNICATIONS
NETWORK IN SUPPORT OF OPERATIONAL MANUEVER FROM THE SEA**

Bryan J. Smith-Major, United States Marine Corps

B.S., University of Arizona, 1982

Master of Science in Information Technology Management-September 1998

Advisors: Rex A. Buddenberg, Information Systems Academic Group

John Osmundson, Command, Control, and Communications Academic Group

Despite the apparent abundance of modern communication technology such as satellites, computers, and fiber-optic transmission systems, communication capacity is a limited resource for littoral operations. The Navy and Marine Corps lack the dedicated networks to support such doctrinal concepts as Operational Maneuver From the Sea (OMFTS). One solution is to develop a Littoral Region Area Network (LRAN). The primary goal of this thesis is to underscore the littoral operating environment and bandwidth requirements. It also investigates reliable seaborne network communication systems complementary to satellite and wireless networks, and proposes an open, standards-based modular architecture, utilizing a network centric design model as the basis for LRAN. It employs modeling and simulation techniques to demonstrate coupling of the system integration processes with the doctrinal concepts of OMFTS.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Other (Information Technology)

KEYWORDS: Networks, Aerostats, Littorals, Operational Maneuver from the Sea (OMFTS), Communications, Modeling and Simulation, IEEE 802.11, ADNS, Marine Corps Tactical Data Network

ANALYSIS OF NATIONAL OVERHEAD INTELLIGENCE COLLECTION (U)

Randall L. Smith-Lieutenant, United States Navy

B.S., United States Naval Academy, 1989

Master of Science in Space Systems Operations-March 1998

Advisors: Dan Boger, Command, Control, and Communications Academic Group

Carl Jones, Information Sciences Academic Group

Space systems provide wide-ranging support to the military and the National Command Authority (NCA) during any developing crisis. This thesis explores how the national systems responded to such an event against the geopolitical backdrop of world events. Each system architecture's capability and role is examined in detail. The entire satellite process is covered from the tasking process and distribution of assets through the dissemination of information to NCA decision makers and on scene military commanders.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Other (Intelligence)

KEYWORDS: Signals Intelligence, Imagery Intelligence, Requirements Process

1998 THESIS ABSTRACTS IS

RE-ENGINEERING THE UNITED STATES MARINE CORPS' RECRUIT DISTRIBUTION MODEL (RDM)

Kevin J. Snoap-Lieutenant, United States Navy

B.S., University of Texas at Austin, 1991

Master of Science in Information Technology Management-September 1998

Advisors: Hemant K. Bhargava, Information Systems Academic Group

Suresh Sridhar, Information Systems Academic Group

The United States Marine Corps accomplishes its mission "to put the right Marine in the right place at the right time with the right skills and quality of life" in a variety of ways. One of the information systems assisting the Marine Enlisted Assignments branch is the Recruit Distribution Model (RDM). This thesis proposes changes to the RDM user interface, data management, assignment model, and analysis capability. With the use of business process re-engineering, process modeling, mathematical modeling, and database design a fully functional prototype has been developed to address each identified change proposal. This re-engineered system includes numerous innovations such as an intuitive navigational scheme using switchboards, and the elimination of manual data entry for data already available in the system. It also provides a number of significant contributions beneficial to the USMC. For instance, the re-engineered system allows the user to objectively analyze different results by comparing four different objective measures, and its mathematical model uses commercial-off-the-shelf products eliminating a proprietary solver. All these changes will empower managers to effectively and efficiently manage the assignment of recruits in order to meet the challenges of the 21st century.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel, and Training, Modeling and Simulation, Other (Database Management Systems)

KEYWORDS: USMC, Databases, Manpower Assignment, Models, Decision Support Systems, Graphical User Interface

OPTIMIZING UNITED STATES MARINE CORPS ENLISTED ASSIGNMENTS

Brian F. Tivnan-Captain, United States Marine Corps

B.S.M.E., University of Vermont, 1992

Master of Science in Operations Research-September 1998

Advisor: Robert F. Dell, Department of Operations Research

Second Reader: Hemant K. Bhargava, Information Systems Academic Group

The United States Marine Corps (USMC) has 156,000 active duty enlisted Marines and annually orders over 90,000 of them to permanently change station. The Commandant of the Marine Corps requires assignments of the "Right Marine, to the right place with the right skills and quality of life." USMC manpower planning uses staffing goals (billet requirements) to capture the Commandant's requirements, but, surprisingly, does not monitor how many Marines fill appropriate staffing goal billets. This thesis finds that although the staffing goals are completely achievable, only 45% of active duty Marines fill a staffing goal billet and 47% of staffing goal billets are under-staffed. The USMC has used the Enlisted Assignment Model (EAM) since the 1970s to help enlisted monitors determine assignments. EAM has several shortcomings. Among these, enlisted monitors reject most of EAM suggested assignments and EAM offers no measure of effectiveness to gauge the quality of its assignments. This thesis presents a network model, EAM-GLOBAL to optimize the by-name assignment of Marines to staffing goal billets. EAM-GLOBAL attempts to assign the "right Marines to the right places" while simultaneously balancing staffing shortages, allowing grade and military occupational specialty substitutions, and minimizing the costs of permanent change of station transfers within the continental United States.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Assignment Model, Staffing Goals, Manpower Models, Transportation Model, Network, Elastic Network Model

**INFORMATION WARFARE
ACADEMIC GROUP**

**James Powell, CAPT, USN
Chair**

FACULTY LISTING IW

Powell, James, CAPT, USN
IW/Po
831-656-2203 (Phone)
831-656-3679 (Fax)
jrpowell@nps.navy.mil

Arquilla, John
Associate Professor
CC/Av
831-656-3450
jarquilla@nps.navy.mil

Cooper, Alfred
Professor
PH/Cr
831-656-2452
acooper@nps.navy.mil

Devlin, Daniel
Installation Commander
DLI-VLC
831-242-5200

Garcia, Vicente
National Security Agency
Cryptologic Chair
EC/Ga
831-656-2110
vgarcia@nps.navy.mil

Irvine, Cynthia
Assistant Professor
CS/Ic
831-656-2461
ceirvine@nps.navy.mil

Jenn, David
Associate Professor
EC/Jn
831-656-2254
jenn@nps.navy.mil

Jones, Carl R.
Professor
IS/Js
831-656-2995
cjones@nps.navy.mil

Morgan, Michael A.
Professor
EC/Mw
831-656-2677
mmorgan@nps.navy.mil

Mullady, Michael, Lt Col, USAF
Curricular Officer
39
831-656-2772
mmullady@nps.navy.mil

Pace, Phillip E.
Associate Professor
EC/Pc
831-656-3286
pace@nps.navy.mil

Schleher, D. Curtis
Professor
IW
831-656-3767
dschleher@nps.navy.mil

Wadsworth, Donald v.Z.
Senior Lecturer
EC/Wd
831-656-2115/3456
dwadsworth@nps.navy.mil

Washburn, Alan R.
Professor
OR/Ws
831-656-3127
awashburn@nps.navy.mil

DEPARTMENT SUMMARY IW

The Information Warfare Academic Group (IWAG) is an interdisciplinary group. Members hold faculty and staff appointments in departments throughout the Naval Postgraduate School and voluntarily hold seats on the IWAG. The IWAG is responsible for management, oversight, and implementation of the Information Warfare and International Electronic Warfare curricula.

Members of the IWAG make significant contributions in Information Warfare/Information Operations studies through their own research and student thesis work. The following pages highlight some of these areas of study. Research conducted by individuals in this unique grouping of academicians is generally associated with their parent department and therefore not listed here.

PROJECT SUMMARIES IW

INFORMATION OPERATIONS TARGETING USING THE VIRTUAL DESIGN TEAM (VDT)

Carl R. Jones, Professor
Information Systems Academic Group
Vicente Garcia, National Security Agency Cryptologic Chair
Department of Electrical and Computer Engineering
LT Raymond Buettner, United States Navy
Information Warfare Academic Group
Sponsor: National Security Agency

OBJECTIVE: Research seeks to determine the feasibility of constructing valid VDT models of target industrial processes such as those associated with the production of weapons of mass destruction (WMD), aircraft production, and ship construction.

SUMMARY: NPS will use Stanford University's VDT/Vite simulation to build virtual models of various target weapons production programs. The research seeks to determine the feasibility of building valid models of target industrial processes using obtainable intelligence input. Once developed the models will be used to identify potential targets for IO attack/defense. Finally a methodology for future VDT use will be developed to allow timely and accurate model adjustments.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Information Warfare)

KEYWORDS: Information Warfare, Information Operations

POLYSTATIC RADAR EXPLOITING GLOBAL BROADCASTING SYSTEM (GBS)

D. Curtis Schleher, Professor
Information Warfare Academic Group and
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: To investigate the vulnerability of the Network Centric Communications System (GBS) to exploitation by a Polystatic Radar System.

SUMMARY: Network Centric Warfare requires a robust communications system which provides high connectivity between all nodes of the information grid. A prototype of such a system is the satellite based Global Broadcasting System (GBS). The necessity for small terrestrial communication antennas requires the GBS to bathe the battle area with a relative high level of (EM) energy. This EM energy is scattered from all objects in the vicinity of area floodlighted by the satellite's antenna beams, and hence provides the potential for the use of a polystatic radar.

Initial studies focused on the potential tactical applications of such a system and experimental verification that the GBS signal had sufficient stability for this type of operation. Systems operations identified included a silent Anti-Ship Cruise Missile (ASCM) and a silent Joint Stars Surveillance System. Correlation measurements using outputs from two GBS ground terminals verified that the communications signals had sufficient stability for polystatic radar operation.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Polystatic Radar, ASCM, Battlefield Surveillance

PROJECT SUMMARIES IW

MISSILE INERTIAL MEASUREMENT UNIT (IMU) MODEL

D. Curtis Schleher, Professor

Information Warfare Academic Group and

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: To develop IMU models that allow a missile's altitude to be determined from telemetry data provided by rate sensors aboard the missile. One model is to be developed for non-rolling missiles that use IMU quartz rate sensors. A second model is to be developed for a rolling missile that uses magnetohydrodynamic rate sensors and a magnetoresistive spin sensor. The model is to provide outputs that are within 2 degrees of the actual missile attitude.

SUMMARY: The basis approach is to develop a SIMULINK model for each of the missiles involved. As part of this model, an animation is developed so that the missile's attitude can be visually observed as the simulation progresses. The simulation accepts digitized strapdown telemetry data which represents distorted rate sensor data. Distortions are due to bias, drift, non-linearities, cross-coupling, sensor noise, and other distortion phenomenon. The model first processes the data to eliminate the known distortions. An Euler transformation is then applied to convert the strap down rates to earth-referenced attitude measurements.

The non-rolling missile simulation has been completed. It has been tested for sensor noise and against digitally generated missile trajectory data. Accuracy with respect to sensor noise has been measured as the order of 0.2 degree. Accuracy with respect to model inaccuracy is less than 1 degree. Testing against CARCO generated data is in progress.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Missile Attitude, SIMULINK, IMU

WIDEBAND DIGITAL COMPRESSIVE RECEIVERS

D. Curtis Schleher, Professor

Information Warfare Academic Group and

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To investigate the application of digital pulse compression techniques to compressive receivers with an objective of increasing the overall bandwidth available from these receivers. To simulate an advanced digital wideband receiver with 8 GHz bandwidth using 1 GHz digital components and determine its bandwidth potential and sensitivities.

SUMMARY: Compressive receivers are advantageous in SIGINT applications requiring wide bandwidth in a dense emitter environment. Present implementations are limited in bandwidth by the analog nature of the design which requires a wideband dispersive delay line and also by the necessity of reading the output data at a digital rate which corresponds to the receiver's bandwidth.

This research describes a wideband digital compressive receiver which mitigates the limitations in the conventional analog design. A new stepped-frequency 8 GHz bandwidth digital design using 1 GHz sub-Nyquist sampling is described. The design was successfully demonstrated using MATLAB simulation. A bandwidth of 8 GHz was achieved using digital components which ran at a maximum 1 GHz clock rate. A 32 MHz resolution was measured as was the capability of separating 25 simultaneous signals occurring at the input of the receiver.

The bandwidth potential of this design was estimated as 16 GHz using 1 GHz digital components. Further research is required to realize the full potential of this design.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Modeling and Simulation

KEYWORDS: SIGINT, Compressive Receiver, Digital Pulse Compression

PROJECT SUMMARIES IW

DETECTION OF LOW PROBABILITY OF INTERCEPT (LPI) RADAR SIGNALS

D. Curtis Schleher, Professor

Information Warfare Academic Group and

Department of Electrical and Computer Engineering

Sponsor: National Reconnaissance Office

OBJECTIVE: To develop a method for detecting Low Probability of Intercept (LPI) radar signals imbedded in noise and other interfering radar signals.

SUMMARY: The approach is to develop an adaptive matched filter processor using deramping and Fast Fourier Transform (FFT) processor techniques. A temporal mask is used to eliminate interfering conventional pulse radar signals. A MATLAB simulation of the processor has been completed. Results show the capability of detecting LPI signals with powers of -102 dBm at the receiver input. Measurement of the LPI bandwidth over a range of 1 MHz-to-50 MHz to 1% accuracy was accomplished.

DoD KEY TECHNOLOGY AREA: Other (Surveillance)

KEYWORDS: SIGINT, LPI Radar, Digital Pulse Compression

PUBLICATIONS/PRESENTATIONS IW

JOURNAL PAPER

Arquilla, J., "Preparing for Information-Age Conflict," *Information, Communication and Society*, (published in two parts), Spring and Summer 1998.

CONFERENCE PAPERS

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1998 THESIS ABSTRACTS IW

DETERMINATION OF A METHODOLOGY FOR CONDUCTING A COST EFFECTIVENESS ANALYSIS STUDY OF THE INTEGRATION OF LOW OBSERVABLES (LO) AND ELECTRONIC WARFARE (EW) IN AIR VEHICLE (AV) DESIGN (U)

Oscar L. Alvarado-Civilian

B.S., Texas A&M University, 1986

Master of Science in Electrical Engineering-September 1998

Advisors: F.H. Levien, Department of Electrical and Computer Engineering

R. Clark Robertson, Department of Electrical and Computer Engineering

CAPT James R. Powell, Information Warfare Academic Group

The advent of decreasing defense budgets coupled with acquisition reform efforts and the high cost of advanced technology applications has produced a definitive need for a methodology to assess the cost benefit of aircraft performance specifications. This methodology must be an iterative process that allows the user to perform design tradeoffs and assess their respective impacts to military utility and cost. This thesis details the approach for conducting an Analysis of Alternatives (AoA), a.k.a. Cost and Operational Effectiveness Analysis (COEA), study to assess the cost-performance tradeoffs of applying Low Observable (LO) technology and Electronic Warfare (EW), either exclusively or mutually, to an aircraft design. The methodology recommends the use of engagement level models and simulations (M&S) coupled with mission level M&S in the absence of a single integrated M&S product. The engagement level analysis is necessary to support high fidelity data requirements that are used by the mission level program to gather relevant measures of effectiveness (MOE) required for the mission effectiveness evaluation. These MOE's are then integrated with corresponding cost data in an effort to examine cost-performance characteristics. Iterative performance modifications can be similarly evaluated in an effort to establish trends, which will assist the user in assessing cost-performance tradeoffs.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Low Observables, Electronic Warfare, Electronic Counter-Measures)

KEYWORDS: Low Observables, Radar Cross Section Reduction, RCS, Electronic Counter-Measures, ECM, Modeling and Simulation, M&S, Mission Level Modeling and Simulation, Enhanced Surface-To-Air Missile Simulation, ESAMS

ORGANIZATIONAL INNOVATION AND REDESIGN IN THE INFORMATION AGE: THE DRUG WAR, NETWAR, AND OTHER LOWER-END CONFLICT

Alexander Berger, Captain, United States Air Force

B.A., University of New Hampshire, 1990

M.S., Troy State University, 1996

Master of Arts in National Security Affairs-March 1998

Advisors: John Arquilla, Information Warfare Academic Group

Scott D. Tollefson, Department of National Security Affairs

The end of the Cold War and the rise of the Information Age have fostered an uncertain security environment which the United States is struggling to master. The purpose of this thesis is to explore the factors that lead complex organizations to initiate large-scale structural change in the face of environmental uncertainty; and more specifically to determine how the rise of the Information Age may change the organizational requirements of the U.S. national security structure. This thesis creates a unique framework for analysis, blending principles of organization and innovation theory with the theory of information-based "netwar."

This study analyzes the organizational structures adopted by several transnational drug cartels and compares them to that of U.S. counternarcotics forces. Next, this thesis reviews a series of recent occurrences pertaining to national security to test whether there are manifestations of netwar threats emerging and whether new and old organizational actors are learning to adapt their structures to gain an advantage over the United States.

1998 THESIS ABSTRACTS IW

Finally, this thesis is both predictive and prescriptive with regard to the issues of organizational redesign. It argues that structural changes are necessary for the United States to ensure the national security in an Information Age. Then it makes recommendations that would help the U.S. security structure redesign itself to become more agile in the face of Information Age threats.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications

KEYWORDS: Organizational Redesign, Information Warfare, Drug War, Innovation, Inter-Service Coordination, Netwar

ARTIFICIAL INTELLIGENCE AND FOREIGN POLICY DECISION-MAKING

Russ H. Berkoff-Major, United States Army

B.S., United States Military Academy, 1981

Master of Science in Defense Analysis-December 1997

Advisors: John Arquilla, Information Warfare Academic Group

Christopher Layne, Command, Control, and Communications Academic Group

With the advent of a global information society, the U.S. will seek to tap the potential of advanced computing capability to enhance its ability to conduct foreign policy decision-making. This thesis explores the potential for improving individual and organizational decision-making capabilities by means of artificial intelligence (AI). The use of AI will allow us to take advantage of the plethora of information available to obtain an edge over potential adversaries. Another purpose of this thesis is to give guidance to the software community as to what policymakers will need in order to improve future decision-making processes. The third purpose is to encourage government and private sector decision-makers to allocate adequate resources to actualize the potential of AI. The method of analysis this thesis uses is to examine U.S. foreign policy decision-making on the cognitive or individual, group, and organizational levels. Using the Cuban Missile Crisis and the Yom Kippur War as test beds for critical analysis, identification of both decision enhancing and impeding functions is accomplished. Finally, a counterfactual analytic framework, using an AI model, tests the likely influence of AI on decision-making. The results substantiate the value of AI as both a decision-making enhancer and an impediment reducer for the policymaker. Additional conclusions are derived that improve the decision-making system and its processes by means of introducing an AI capability.

KEYWORDS: Artificial Intelligence, Foreign Policy, Cuban Missile Crisis, Yom Kippur War, Decision-Making, Cognitive Theory, Group Dynamics, Organizational Theory, Bureaucratic Politics, Decision Modeling, Decision-Making

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Modeling and Simulation

SINGLE-FREQUENCY MEASUREMENTS USING UNDERSAMPLING METHODS

Eng S. Chia-Major, Republic of Singapore Air Force

B.S., National University of Singapore, 1989

Master of Science in Electrical Engineering-March 1998

Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering

Second Reader: Curtis D. Schleher, Information Warfare Academic Group

The objective of this study is to verify the Symmetrical Number System (SNS) undersampling receiver architecture using software and to investigate implementation issues using digital signal processing (DSP) hardware. In the software design, a MATLAB program is written to determine a single sinusoidal input frequency using this receiver architecture. Each channel of the SNS undersampling receiver consists of a low speed ADC, a discrete Fourier transform followed by a constant threshold device to detect the signal's frequency bin. The detected frequency bins are then recombined in an SNS-to-decimal algorithm to recover the frequency of the signal. Error rate performance in a Gaussian noise environment at the input stage is evaluated. In the hardware design, a sinusoidal waveform is digitized, discrete Fourier transformed and

1998 THESIS ABSTRACTS IW

converted from the SNS format to a decimal value using a single channel digital signal processor. Implementation difficulties and design issues are discussed.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Symmetrical Number System, Symmetrical Folding, Undersampling, Discrete Fourier Transform

21ST CENTURY SUBMARINE INFORMATION OPERATIONS (U)

Scott R. Coughlin-Lieutenant, United States Navy

B.S., United States Naval Academy, 1992

Master of Science in Systems Engineering-September 1998

Advisor: Vicente C. Garcia, Jr., National Security Agency Cryptologic Chair

Second Reader: CAPT James R. Powell, Information Warfare Academic Group

The United States Submarine Force has a long and distinguished history of providing national decision makers with Intelligence, Surveillance, and Reconnaissance services allowed by the unique access granted by the submarine's attribute of stealth. To maximize the effectiveness of our submarine fleet to continue to perform tomorrow's Information Operations (IO) missions requires evolution. This thesis will explore how to best prepare our submarine fleet to perform Information Operations.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Conventional Weapons, Electronic Warfare, Surface/Under Surface Vehicles - Ships and Watercraft, Sensors, Directed Energy Weapons, Air Vehicles, Space Vehicles, Computing and Software

KEYWORDS: Submarine, Information Operations, Information Warfare, Intelligence, Reconnaissance, Surveillance

DEVELOPMENT OF HIGH POWER MICROWAVE (HPM) ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION (ACTD) FOR ASCM DEFENSE OF THE ARG (U)

Brian P. Dulla-Lieutenant, United States Navy

B.S., United States Naval Academy, 1991

Master of Science in Applied Physics-December 1997

Advisor: Captain James R. Powell, Information Warfare Academic Group

CLASSIFIED ABSTRACT

KEYWORDS: High Power Microwaves (HPM), Directed Energy Weapon, Anti-Ship Cruise Missile Defense, Microwave Coupling

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Directed Energy Weapons

1998 THESIS ABSTRACTS IW

AN ASSESSMENT OF WIRELESS LOCAL AREA NETWORKS: VULNERABILITIES AND POTENTIAL MILITARY IMPLEMENTATION (U)

**Cynthia M. Fulmer-Lieutenant Junior Grade, United States Navy
B.S., United States Naval Academy, 1995**

Master of Science in Systems Engineering-September 1998

**Advisors: CAPT James R. Powell, Information Warfare Academic Group
Vicente Garcia, National Security Agency Cryptologic Chair**

Wireless network technology provides improved services such as flexibility and high data rates at the promise of full mobility. The emergence of wireless local area networks (WLANs) has changed the role of wired communications in the face of this lower-cost, easy to implement, flexible technology. Wireless networks have mainly been implemented for civilian use. However, there is tremendous potential for WLANs in the military, from everyday administrative to operational shipboard implementation, to use by the Marine Corps during amphibious assaults and other ground maneuvers. The widespread use of WLANs, however, has occurred without certain key issues such as the security and vulnerabilities of WLANs being addressed. The objective of this thesis is to provide the Department of Defense with critical information on WLANs, a tutorial on how WLANs work, and to address the issue of vulnerabilities. This thesis provides a background of WLANs, looking at wireless communication, wired LANs, and the IEEE 802.11 standard for WLANs. It discusses vulnerabilities of WLANs and provides an initial vulnerability assessment and provides an overview of how WLANs have been implemented in the military, its potential for future use, and the security issues involved with military implementation.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Wireless Local Area Networks, Local Area Networks, Wireless Communication, IEEE 802.11, Wireless Security

LOW-END SOLUTIONS TO THE UNDERGROUND DILEMMA

Brian M. Hayes-Captain, United States Army

B.S., Suffolk University, 1986

Master of Science in Defense Analysis-December 1997

and

David A. Roddenberry Jr.-Major, United States Army

B.S., Western Carolina University, 1986

Master of Science in Defense Analysis-December 1997

**Advisors: John Arquilla, Information Warfare Academic Group
Gordon H. McCormick, Command, Control, and Communications Academic Group**

Both the 1981 Israeli Raid on the Osirak nuclear reactor in Iraq and the Gulf War, served notice to would-be proliferators that, in order to survive in the face of the conventional superiority of the United States and its allies, means must be developed to protect those assets deemed valuable or strategic in nature. Many would-be proliferators have chosen to develop underground structures, referred to as hardened and deeply buried targets (HDBT), as the preferred means to protect and hide their efforts to obtain weapons of mass destruction (WMD). To counter this trend, the U.S. relies almost entirely upon a policy of negotiated peacetime elimination or reduction of WMD/HDBT through diplomatic channels. Yet, if these efforts fail and the necessity for preemption or prevention emerges, instead of immediately relying on direct force alternatives, an indirect low-level interdiction method may be both more appropriate and available.

This thesis explores an alternative means by which the vulnerabilities of HDBT/WMD sites may be exploited through the use of low-level, indirect, counter-force strategies. This exploration of alternative HDBT interdiction approaches concludes that low-level counterforce strategies can complement existing counterproliferation initiatives, when employed as components of an overall campaign designed to deny and disrupt a would-be proliferator's progress.

1998 THESIS ABSTRACTS IW

KEYWORDS: Counterproliferation, Hardened and Deeply Buried Targets (HDBT)

DoD KEY TECHNOLOGY AREA: Other (Weapons of Mass Destruction)

WINDOWS NT 4.0 SECURITY FOR IT-21

Kevin S. Hinton-Lieutenant, United States Navy

B.S., United States Naval Academy, 1991

Master of Science in Systems Engineering-September 1998

Advisors: CAPT James R. Powell, Information Warfare Academic Group

Vicente C. Garcia, National Security Agency Cryptologic Chair

The Navy is jumping into the information technology revolution by procuring commercial off-the-shelf computer networking hardware and software. This strategy is termed IT-21 and revolves around minimum standards set in January 1997. These standards designate Microsoft Windows NT 4.0 as the computer network operating system for tactical and administrative networks. Windows NT is inexpensive and easy to install and maintain, but it is a young operating system and has proved to be full of vulnerabilities. This may make the Navy's exchange of administrative and tactical information highly vulnerable to a determined and technical foe as well as the teenage hacker. There are methods to reduce the risk, however. Windows NT can be configured and implemented to significantly reduce the number of vulnerabilities. There are also a number of commercial security products that monitor the configuration of Windows NT, scan for security vulnerabilities, and detect near real time intrusions into Windows NT networks. The application of a combination of these techniques can drastically improve the security of our information exchange systems in the 21st Century.

GREAT POWERS, WEAK STATES, AND ASYMMETRIC STRATEGIES

Michael R. Lwin-Captain, United States Army

B.S., Georgetown University, 1989

Master of Science in Defense Analysis-December 1997

Advisors: John Arquilla, Information Warfare Academic Group

Christopher Layne, Command, Control, and Communications Academic Group

On the verge of the twenty-first century, America finds itself in the position of a great power with dominant military technology. This thesis examines the possibility that weaker states may be able to strategically innovate and defeat us in war despite our technological advantages. The purpose of the thesis is to survey what type of strategic innovations, also known as asymmetric strategies, are possible and to examine the conditions under which they may be successful.

This thesis begins by defining asymmetric strategies using a comprehensive model of strategy developed by Rear Admiral J.C. Wylie. The thesis also examines four variables which may explain the success or failure of asymmetric strategies. To illustrate possible asymmetric strategies and examine the contextual conditions under which they work, the thesis considers the cases of the Italo-Ethiopian war of 1935-36, the Russo-Finnish War of 1939-40, and the American-North Vietnamese War of 1965-73. The thesis finds that the four variables have significant explanatory power for the success or failure of these strategies. The thesis concludes by examining strategic implications for the United States, both as a possible opponent of weak states and as a supporter of a weak state faced by a great power threat.

KEYWORDS: Strategy, Strategic Innovation, Asymmetric Conflict and Military Technology, Future Wars, Italo-Ethiopian War, Russo-Finnish War, Vietnam

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Conventional Weapons, Other (Strategy)

1998 THESIS ABSTRACTS IW

INFLUENCE MODELING STATE-TERRORISM FOR INFORMATION OPERATIONS (U)

Russell L. Marsh-Lieutenant, United States Navy

B.S., Oregon State University, 1994

Master of Science in Systems Engineering-September 1998

Advisor: CAPT James R. Powell, Information Warfare Academic Group

Second Reader: Gordon McCormick, Special Operation Low Intensity Conflict (SOLIC) Curriculum Committee

The purpose of this research is to use Situational Influence Assessment (SIAM) Module created by SAIC to model a terrorist organization that is attempting to disrupt negotiations between two state actors. The SIAM model was used to analyze the causal relationships and to look for the various leverage points at which to apply Information Operations (IO) that will minimize the effects of terrorist action, and influence the terrorists decision making process. The actors in a specific scenario were modeled as to how leadership could be influenced. After analysis with SIAM, possible IO options were created, incorporated into the model and tested to see how effective the IO options were at influencing the decision-making process. Once the IO options had been tested, a suggested plan of action results. Both a preventative approach and reactive approach are proposed. The preventative approach is intended to reduce the effectiveness of terrorism and impede the conduct of the terrorist organization. The reactive approach provides options for responding to terrorist activities without alienating the surrounding populace.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: SIAM, Terrorism, Information Operations, Peace Negotiations

AN OPERATIONAL HIGH POWER MICROWAVE APPLICATION FOR INFORMATION OPERATIONS (U)

Daniel J. Miller-Lieutenant, United States Navy

B.S., University of Colorado, 1992

Master of Science in Systems Engineering-September 1998

and

David P. Shewfelt-Captain, United States Marine Corps

B.S., United States Naval Academy, 1991

Master of Science in Systems Engineering-September 1998

Advisor: CAPT James R. Powell, Information Warfare Academic Group

Second Reader: Michael A. Morgan, Department of Electrical and Computer Engineering

This thesis documents the results of a feasibility demonstration of a high power microwave application for Information Operations and recommends future improvements to the system. Success in the Information Operations (IO) and Information Warfare (IW) arena requires advanced capabilities. This thesis describes one such capability that would provide commanders with courses of action previously unavailable.

DoD KEY TECHNOLOGY AREA: Directed Energy Weapons

KEYWORDS: Information Operations, High Power Microwave

1998 THESIS ABSTRACTS IW

COMPUTER NETWORK ATTACK (U)

David C. Rice-Lieutenant, United States Navy

B.S., United States Naval Academy, 1994

Master of Science in Systems Engineering-September 1998

Advisors: CAPT James R. Powell, Information Warfare Academic Group

Vicente C. Garcia, National Security Agency Cryptologic Chair

The convergence of computing and telecommunications places new and complex demands on U.S. intelligence agencies. Techniques in Computer Network Attack are discussed as a means to cope with the new communications environment.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, Communications, Other (Computers and Intelligence)

KEYWORDS: Information Operations, Information Warfare, Computer Network Attack

MODELING THE EFFECTS OF INFORMATION OPERATIONS

ON AN ADVERSARY DECISION-MAKER (U)

Walter E. Rogers, II-Lieutenant, United States Navy

B.A., Virginia Military Institute, 1991

Master of Science in Systems Engineering-September 1998

Advisor: CAPT James R. Powell, Information Warfare Academic Group

Second Reader: R. Mitchell Brown, Department of National Security Affairs

The potential for crisis and conflict exists in almost every region of the globe in today's unstable world. In this fiscally constrained time, however, the United States cannot afford to expend resources and lives by employing forces in every crisis. This makes the use of Information Operations as an instrument to deter conflict increasingly desirable. Information Operations have the potential to accomplish U.S. strategic goals more effectively, with reduced political risk, and with comparatively less physical risk to our armed forces. Few commanders, however, willingly commit to a course of action before they have a firm grasp of the expected results. Unlike the use of physical means, whose effectiveness can be measured in terms of CEP and PK, the effects of Information Operations on an adversary's decision process cannot be quantified in the same way because the outcome of this process does not display physical phenomena. This thesis applies a software tool entitled Situational Influence Assessment Module (SIAM) to examine how a specific adversary's decision process can be modeled and what effects Information Operations may have on influencing that process.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Information Warfare)

KEYWORDS: IO Modeling and Simulation, SIAM

COMPUTER NETWORK RESEARCH IN THE WINDOWS NT ENVIRONMENT (U)

Bruce G. Ward-Lieutenant, United States Navy

B.S., State University of New York (Albany), 1991

Master of Science in Systems Engineering-September 1998

Advisors: Vicente C. Garcia, National Security Agency Cryptologic Chair

CAPT James R. Powell, Information Warfare Academic Group

The world is witnessing an explosion of computer networking that is quickly changing the way that the United States Armed Forces and Department of Defense (DoD) agencies, such as the National Security Agency (NSA), need to focus their resources. U.S. adversaries and rogue nations as a venue of aggression can easily attain attacks on the United States National Information Infrastructure (NII).

1998 THESIS ABSTRACTS IW

This research documents the development of the Naval Postgraduate School's Computer Network Research Lab and discusses at the classified level different techniques toward educating the warfighters and increasing the technical knowledge base of our military leadership, which will assuredly be required in future conflict and the cyber battle field.

DoD KEY TECHNOLOGY AREA: Computer and Software

KEYWORDS: Computer, Network Research, Windows NT

**SPACE SYSTEMS
ACADEMIC GROUP**

**Rudolf Panholzer
Chair**

FACULTY LISTING SP

Panholzer, Rudolf
Professor and Chair
SP/Pz
831-656-2154/2278 (phone)
831-656-2816 (fax)
rpanholzer@nps.navy.mil

Agrawal, Brig
Professor
AA/Ag
831-656-3338
bnagrawa@nps.navy.mil

Baldwin, Craig
Navy Space Systems Chair
831-656-2231
cwbaldwi@nps.navy.mil

Betterton, Tom, RADM
Naval Space Technology Program
Chair
SP/Be
831-656-3765
betterton@ssdd.nrl.navy.mil

Biblarz, Oscar
Professor
AA/Bi
831-656-3096
obiblarz@nps.navy.mil

Boger, Dan
Professor
CC/Bo
831-656-3671/2607
dboger@nps.navy.mil

Cleary, David
Associate Professor
PH/CI
656-2828
cleary@nps.navy.mil

Daniel, Charles
NASA Michael J. Smith Space
Systems Chair
831-656-3765
ccdaniel@nps.navy.mil

Danielson, Donald
Professor
MA/Dd
831-656-2622
dad@nps.navy.mil

Eagle, James
Professor
UW/Er
831-656-2654/2214
jeagle@nps.navy.mil

Fouts, Douglas
Associate Professor
EC/Fs
831-656-2852
fouts@nps.navy.mil

Garcia, Vicente
National Security Agency
Cryptologic Chair
EC/Ga
831-65-2325/2110
vcgarcia@nps.navy.mil

Gopinath, Ashok
Assistant Professor
ME/Gk
831-656-3400
gopinath@nps.navy.mil

Jones, Carl R.
Professor
SM/Js
831-656-2995
crjones@nps.navy.mil

Loomis, Herschel H.
Professor
EC/Lm
831-656-3214/2080
hloomis@nps.navy.mil

Michael, Sherif
Associate Professor
EC/Mi
831-656-2252/2082
michael@nps.navy.mil

Newberry, Conrad
Professor
AA/Ne
831-656-2892
cfnewber@nps.navy.mil

Olsen, Chris
Associate Professor
PH/Os
831-656-2019/3330
olsen@physics.nps.navy.mil

Powers, John
Professor
EC/Po
831-656-2679
jpowers@nps.navy.mil

Ross, Alan
TENCAP Chair
SP/Ra
831-656-3769
aross@nps.navy.mil

Ross, I. Michael
Assistant Professor
AA/Ro
831-656-2074
imross@nps.navy.mil

Wadsworth, Don v.Z.
Professor
CC/Wd
831-656-3456
dwadsworth@nps.navy.mil

FACULTY LISTING SP

Weatherford, Todd
Assistant Professor
EC/Wt
831-656-3044
weatherf@nps.navy.mil

Welch, Joe, CDR
Curricular Officer
Code 31
831-656-2491/fax: 3125
wwelch@mnltry.nps.navy.mil

Wight, Randy
Visiting Instructor
SP/Wt or EC/Wr
831-656-3403
rwight@nps.navy.mil

Wilson, Lonnie
Research Associate Professor
EC/Wi
831-656-2838/2299
wilson@nps.navy.mil

GROUP SUMMARY SP

The Space Systems Academic Group (SSAG) is an interdisciplinary association providing direction and guidance for the Space Systems Engineering and Space Systems Operations curricula. The SSAG relies on faculty and facilities support from the Departments of Aeronautics and Astronautics, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Operations Research, Physics, and Systems Management. The SSAG also benefits from the support of four Academic Space Chairs: Navy TENCAP Space Chair, Naval Space Technology Program Chair, Navy Space Systems Academic Chair, and Michael J. Smith Space Systems Chair.

The mission of the SSAG is threefold. The SSAG designs the curricula to provide a firm foundation in the broad array of disciplines which comprise the focus for Space Systems Engineering and Space Systems Operations. The SSAG also directs space research at NPS, thereby promoting practical learning opportunities through both theoretical and hardware-based thesis research. The third role of the SSAG is to ensure that officer students in the Space Systems Curricula receive practical experience through experience tours. A six-week experience tour is taken by each officer student hosted by any of a number of facilities from industry, Federal Government, or other universities.

Marrying the academic goals of the SSAG with the practical application of space technology for defense needs, the ongoing small satellite project provides an environment ideal for students to gain experience in design, development, testing, system integration, and operations of spacecraft and payloads. Officer students are exposed to space related research topics as well as formal classroom instruction. Many officer students have chosen research topics directly related to the small satellite design studies program.

In the 1998 academic year, officer students in the Space Systems Curricula and participating faculty from several departments were involved with the Petite Amateur Navy Satellite (PANSAT) project.

1998 SSAG membership includes:

Professor Rudolf Panholzer (Space Systems), Chair
Professor Brij Agrawal (Aeronautics and Astronautics)
Alan Ross (Space Systems), Navy TENCAP Space Chair
Craig Baldwin (Space Systems), Navy Space Systems Academic Chair
Tom Betterton (Space Systems), Naval Space Technology Program Chair
Professor Oscar Biblarz (Aeronautics and Astronautics)
Professor Dan Boger (Command, Control, and Communications Academic Group)
Associate Professor David Cleary (Physics)
Charles Daniel (Space Systems), NASA Michael J. Smith Space Systems Chair
Professor Donald Danielson (Mathematics)
Professor James Eagle (Undersea Warfare)
Associate Professor Douglas Fouts (Electrical and Computer Engineering)
Vicente Garcia (Electrical and Computer Engineering), National Security Agency Cryptologic Chair
Assistant Professor Ashok Gopinath (Mechanical Engineering)
Lois Scaglione (Space Systems), NASA Michael J. Smith Space Systems Chair
Professor Carl R. Jones (Information Systems Academic Group)
Visiting Assistant Professor Barry Leonard (Aeronautics and Astronautics)
Professor Herschel H. Loomis (Electrical and Computer Engineering)
Associate Professor Sherif Michael (Electrical and Computer Engineering)
Professor Conrad Newberry (Aeronautics and Astronautics)
Associate Professor Chris Olsen (Physics)
Professor John Powers (Electrical and Computer Engineering)
Associate Professor I. Michael Ross (Aeronautics and Astronautics)
Professor Don v.Z. Wadsworth (Command, Control, and Communications Academic Group)
Assistant Professor Todd Weatherford (Electrical and Computer Engineering)
Instructor Randy Wight (Electrical and Computer Engineering)
Research Associate Professor Lonnie Wilson (Electrical and Computer Engineering)
CDR Joe Welch (Curricular Officer)

GROUP SUMMARY SP

SMALL SATELLITE DESIGN STUDIES PROGRAM

Directed by Professor Rudolf Panholzer, the Small Satellite Design Studies Program is part of the Spacecraft Technology research effort incorporating proven and leading-edge technology in a space system development project. The Small Satellite Design Studies project continues in the development of the Petite Amateur Navy Satellite (PANSAT). PANSAT is a small satellite being developed at NPS by officer students, faculty, and staff, for launch into a low-Earth orbit as a secondary payload via the Shuttle Hitchhiker program. Launch and integration is provided by the Department of Defense Space Test Program (STP).

PANSAT will provide a global, digital message relay system. Messages received by the spacecraft will be stored on-board until they are commanded to be down-linked to a ground station. Communications will be done using direct sequence spread spectrum in the amateur radio ultra-high frequency (UHF) band. Communications are centered at 436.5 MHz with approximately 2.5 MHz of bandwidth. Transmission data rate will be 9.842 kbps using a 7-bit shift register with taps at 7 and 1 for the generation of the pseudonoise (PN) code.

Thorough testing of the electronics and software which controls the on-board processing was performed and integration with the Shuttle Hitchhiker carrier system was completed in FY 1998. Subsystem environmental testing was performed at NPS on various spacecraft electronics modules to ensure survivability for both the launch and space environments. Testing included random vibration and thermal-vacuum cycling. Following system integration, the spacecraft was delivered to NASA Goddard Space Flight Center (GSFC). System level vibration testing was performed at NASA/GSFC and final checkout and integration procedures were completed for delivery to NASA Kennedy Space Center and integration with the *Discovery* Orbiter.

PANSAT Development

The PANSAT spacecraft consists of the digital control subsystem (DCS), electrical power subsystem (EPS), communications payload (COMM), and the mechanical structure. Progress was made in FY98 in all areas of hardware development to successfully complete the spacecraft and deliver it to NASA/GSFC. Functional testing was performed at NPS to verify software algorithms and control of hardware electronics. These included verification tests of the battery charge algorithm, radio frequency communications software control, and testing of scenarios to use redundancy in the design. Work was also completed in development of a robust, portable test setup used at NASA/GSFC during integration with the Shuttle Hitchhiker carrier and ejection system.

Work was also performed in FY98 to establish the PANSAT ground station for communication with the orbiting satellite from NPS. The PANSAT ground station includes the radio frequency equipment, computers, and peripherals necessary for digital communications with the satellite. The ground station is located at NPS to further support the educational objectives of the project. PANSAT communications opportunities occur each day in three or four consecutive passes of approximately five minutes mean duration. Antennas are located on top of a 35-foot crank-up tower with computer-controlled rotors for pointing in azimuth and elevation. Doppler compensation is also accommodated for the low-Earth orbiting satellite through computerized control of two frequency synthesizers, one for the up-link and one for the down-link.

Programmatic Developments

Programmatic issues include maintaining a dialogue between NPS, the DOD Space Test Program (STP), and NASA during the FY98 period for the STS-95 Shuttle flight. Coordination and filing with other external organizations was done to provide use of the frequency spectrum and to receive timely updates of the satellite's orbital information. This was done through the Federal Communications Commission and the U. S. Naval Space Command, respectively. PANSAT was integrated as part of the third International Extreme-Ultraviolet Hitchhiker (IEH-3) payload to be launched on the STS-95 Shuttle mission, October 29, 1998. Final preparations for the Shuttle flight included closing out NASA safety issues, flight operations, and contingencies for PANSAT as a Shuttle payload.

PROJECT SUMMARIES SP

NAVAL SPACE ACADEMIC CHAIR

Craig Baldwin, Navy Space Systems Academic Chair Professor
Space Systems Academic Group
Sponsor: Naval Space Command

OBJECTIVE: The objective of the Chair Professorship is to provide direct interaction between NPS and the Naval Space Command to further promote and guide a focused instructional and research program in Space Systems at NPS which will support all aspects of naval space systems, including education, research, development, procurement, and operations. The program provides valuable opportunities for professional development of both faculty and students at NPS and is an important investment in the Department of the Navy's strategy for Space Systems.

THESES DIRECTED:

Gloss, L.E., "The Russian Federation and the International Space Station: Leveraging Russian Space Strengths to Control Its Missile Technology Proliferation," Master's Thesis, Naval Postgraduate School, September 1998.

Wickline, J.O., "Teledesic's Capabilities to Meet Future Department of Defense Wideband Communications Requirements," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Space Vehicles, Electronics

KEYWORDS: Space Systems

USING SLBMS FOR LAUNCHING SMALL SATELLITES

Craig Baldwin, Navy Space Systems Academic Chair Professor
Space Systems Academic Group
I. Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Space Command

OBJECTIVE: Space support to the warfighter may be enhanced significantly by providing a launch on demand capability to support the growing and dynamic C4ISR requirements. The purpose of this proposal is to study how SLBMs may be used to launch small communication satellites in Earth orbit. The proposal includes a conceptual design of a small communication satellite that can be launched using the Trident missile.

SUMMARY: A five-member team of three faculty members (Professors Baldwin, Ross and Fahroo) and two students (CDR Gleason and LT Molinari) was formed to solve the problem. The problem is divided into two major sub-problems: launch trajectory optimization to put the maximum payload in LEO, and orbital analysis (payload types, constellation requirements, mass constraints etc.). A computer code for the launch trajectory optimization was written in MATLAB. It is based on discretizing a generic launch profile and optimizing the discrete points for the Trident data. The Trident I (C4) data was modeled as a proof-of-concept.

The orbital analysis has progressed to the point of identifying potential orbits, payload ideas and lifetime requirements. The students are trying out these ideas by means of the standard simulation package called the Satellite Tool Kit (STK). The launch and orbit analysis will be patched together at the end of this quarter. Preliminary small satellite design is underway and will be completed next quarter. The end of this analysis will help to identify the orbit and constellation requirements to achieve certain DoD objectives.

PUBLICATIONS:

Fahroo, F. and Ross, I. M., "Costate Estimation by a Legendre Pseudospectral Method," *Journal of Guidance, Control and Dynamics*, submitted 1998.

PROJECT SUMMARIES SP

CONFERENCE PRESENTATION:

Fahroo, F. and Ross, I. M., "Costate Estimation by a Legendre Pseudospectral Method," AIAA Guidance, Navigation and Control Conference, Boston, MA, 10-12 August 1998.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: SLBM, TRIDENT II, Launch Vehicles, Small Spacecraft

NAVAL SPACE TECHNOLOGY PROGRAM CHAIR PROFESSORSHIP

RADM Thomas Betterton, USN (Ret.), Naval Space Technology Program Chair Professor

Space Systems Academic Group

Sponsor: Naval Space Technology Program

OBJECTIVE: The objective of the Chair Professorship is to assign a Naval Space Technology Program representative at NPS to increase expertise and interactions between technical personnel, promote advanced level research efforts, explore areas of mutually beneficial joint research that provides maximum benefit to both the Naval Space Technology Program and the Naval Postgraduate School, enhance technology transfer, and contribute to the academic resources of the NPS in order to enhance the advanced education of military officers.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Sensors

KEYWORDS: Space Technology

NATIONAL SECURITY AGENCY/COMMAND, CONTROL, COMMUNICATIONS,

COMPUTERS AND INTELLIGENCE COMPUTER NETWORK ATTACK

RESEARCH LABORATORY AND THESIS RESEARCH SUPPORT

Vicente Garcia, National Security Agency Cryptologic Chair Professor

Space Systems Academic Group and

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: An information operations computer network attack (CNA) laboratory sponsored by the National Security Agency (C4) shall be procured for the Naval Postgraduate School in support of the National Security Agency visiting professor as assigned as the NPS Cryptologic Chair. This laboratory shall support the following NPS curricula: Information Warfare, Computer Science, and the Department of Electrical and Computer Engineering. NPS faculty, staff and graduate students shall assist the Cryptologic Chair to establish this laboratory. Graduate students will investigate and obtain computer network attack hardware/software/firmware and the application of applying advanced information operations (IO) concepts. The student will investigate the software, hardware, applications involved which are essential to the IO mission. Another aspect of their research will be the conduct of simulations network studies. The ultimate objective of this effort is to enhance and complement their direct support of the mission of the National Security Agency.

DoD KEY TECHNOLOGY AREA: Other (Information Operations)

KEYWORDS: Exploit, Protect, Network, Security, Computer, Software, Sensors, OSI, Materials, Communications Networking, Data Processes

PROJECT SUMMARIES SP

NATIONAL SECURITY AGENCY/K51 CRYPTOLOGIC RESEARCH LABORATORY AND THESIS RESEARCH SUPPORT

**Vicente Garcia, National Security Agency Cryptologic Chair Professor
Space Systems Academic Group and
Department of Electrical and Computer Engineering
Sponsor: National Security Agency**

OBJECTIVE: A Cryptologic Research Laboratory (CRL) sponsored by the National Security Agency (K51) will be stood up at the Naval Postgraduate School to support the NSA visiting professor who is assigned as the NPS Cryptologic Chair. This laboratory shall support the following NPS curricula: Information Warfare and the Department of Electrical and Computer Engineering. NPS faculty, staff, and graduate students shall assist the Cryptologic Chair to establish this laboratory. Graduate Students will investigate automated signal detection and modulation recognition techniques. Specifically, multi-resolution wavelets, feature extraction based on conventional digital signal processing spectral analysis with multi-resolution decomposition techniques and a neural network classifier shall be researched to include the non-conventional higher-order cyclostationary processes.

DoD KEY TECHNOLOGY AREA: Other (Cryptology)

KEYWORDS: COMINT, BLEEPER, VSAT, OSI, TCP, IP, Modulation, Cyclostationary, Protect, Network, Security, Detection, Recognition, Exploit, Computer, Software, Sensors

TIME DIFFERENCE OF ARRIVAL ESTIMATION BASED ON WAVELET SCALES

Ralph D. Hippenstiel, Associate Professor

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

**Sponsors: Navy Tactical Exploitation of National Capabilities (TENCAP) Office and
Naval Postgraduate School**

OBJECTIVE: Support Military Applications in Space by providing a fast way to localize potential emitters. Demonstrate the feasibility of Time Difference of Arrival (TDOA) estimation using a unique method based on multi-rate and proportional bandwidth processing techniques.

SUMMARY: Time Difference of Arrival (TODA) estimates were obtained by using the wavelet transform as a de-noising tool prior to correlating the data. Simulation studies utilized a generic Barker sequence encoded BPSK signal and a complex-valued baseband GSM signal. New de-noising procedures were devised and tested. Significant improvement in localization ability due to a smaller MSE of the differential time of arrival were obtained. The research work is currently in progress. It has not been published and will be part of a student's thesis who will be graduating in March 1999.

DoD TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: Geo-Location, Wavelet Processing, Signal Processing, Time Difference of Arrival (TDOA) Estimation

PROJECT SUMMARIES SP

THEATER BALLISTIC MISSILE DEFENSE (TBMD) – MULTI-SENSOR FUSION, TRACKING, AND TARGETING TECHNIQUES

Robert G. Hutchins, Associate Professor

Harold A. Titus, Professor Emeritus

Department of Electrical and Computer Engineering

Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: Sensor fusion and tracking of theater ballistic missiles for minimum time intercept.

SUMMARY: Present space sensor devices have the potential to provide the shooter with much earlier ballistic missile launch detection and location information. The intent of this research is to develop algorithms that will provide the earliest possible detection and tracking information by fusing information at the earliest possible time, by alerting the shooter with detection data and imprecise location information at the earliest possible time, and by tracking after data fusion for more accurate and faster target location and identification. The fusion algorithm must bring to bear all sensor assets available to cover a threatened launch area, including space, shipboard, aircraft, and UAV sensors, and to fuse these observations as quickly as they are obtained at a central site. CY 98 work has led to a Kalman-based interactive multiple model design for boost and transition phase tracking of a TBM. The more recent focus has been on spacecraft-to-AEGIS hand-off issues and on backfitting algorithms to determine TBM launch locations in the shortest possible time. Simulations to test proposed sensor fusion and tracking algorithms have been developed, and classified missile trajectory data has been acquired for more realistic algorithm tests. Testing and algorithm development is on going.

PUBLICATION:

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile During Boost Phase," *Signal and Data Processing of Small Targets 1998*, O. Drummond, (ed.), *Proceedings of the SPIE*, Vol. 3373, pp. 528-537, 1998.

CONFERENCE PRESENTATION:

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile During Boost Phase," SPIE Signal and Data Processing of Small Targets Conference, Orlando, FL, April 1998.

THESES DIRECTED:

San Jose, A.P., "Theater Ballistic Missile Defense – Multisensor Fusion, Targeting, and Tracking Techniques," Master's Thesis, Naval Postgraduate School, March 1998.

Britt, P.T., "Kalman Filter Tracking and Backfitting for Boost Phase Theater Ballistic Missiles," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Sensor Fusion, Target Tracking, Theater Ballistic Missile Defense

PROJECT SUMMARIES SP

PROJECT GUSTY ORIOLE

Herschel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

RADM Thomas C. Betterton, USN (Ret), Naval Space Technology Chair

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition, processing, and communications of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and for SS4041 and SS4051, Military Space Systems and Technologies.

SUMMARY: Investigated algorithms and architectures of systems for the production, distribution, and analysis of tactical information. Investigated architectures of space-borne computer systems. Investigated operational problems concerned with the employment of tactical information for decision making and targeting. Planning a multi-source maritime situational awareness experiment for early 1999. Planned the inclusion of a major space system architecture study in SS4051 in winter 1999.

PUBLICATION:

Loomis, H.H., Jr. and Betz, J., "Low Probability of Intercept Communications (U)," *MILCOM98 Classified Conference Record*, MITRE Corp., Bedford, MA, October 1998.

CONFERENCE PRESENTATION:

Loomis, H.H., Jr. and Betz, J., "Low Probability of Intercept Communications (U)," MILCOM98 Classified Session, MITRE Corp., Bedford, MA, October 1998.

THESES DIRECTED:

Strozzo, P.G., "Detection and Classification of Digital Communication Signals Using Second and Higher Order Cyclostationary Features (Parts I & II) (U)," Master's Thesis, Naval Postgraduate School, June 1998.

Galina, J., "Maritime Situational Awareness-Dedicating the On-Board Processor for a Space Based Solution," Master's Thesis, Naval Postgraduate School, September 1998.

Jackson, A.K., "An Architecture for Maritime Situational Awareness," Master's Thesis, Naval Postgraduate School, September 1998.

Dines, S., "Space Based Information Operations," Master's Thesis, Naval Postgraduate School, December 1998.

Mateo, N., "The Effects of Time Varying Doppler on Cyclic Spectral Analysis," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Sensors

KEYWORDS: Tactical Information, Maritime Situational Awareness

PROJECT SUMMARIES SP

RADIANT BRASS EXPLOITATION

Richard C. Olsen, Associate Professor

Philip L. Walker, Associate Research Professor

Department of Physics

Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: To write a proposal and test plan to develop a method of using satellite data to predict the performance of laser designators at desert sites.

SUMMARY: The proposal was written up and submitted to TENCAP. A method of approach for this problem was devised and a test plan is being written. Funding is expected shortly.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Environment, Lasers, Transmission

INFRARED SUBMARINE STUDIES

Richard C. Olsen, Associate Professor

Department of Physics

Sponsor: Chief of Naval Operations

OBJECTIVE: To address the application of infrared imagery to anti-submarine warfare.

SUMMARY: Infrared observations were analyzed and reported.

THESES DIRECTED:

Robson, R., (classified title), Master's Thesis, Naval Postgraduate School, June 1998.

Stubblefield, M., (classified title), Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Remote Sensing, Mine Warfare, TENCAP

FERROELECTRICITY RESEARCH NEWSLETTER

Rudolf Panholzer, Professor

Space Systems Academic Group

Sponsor: Office of Naval Research

OBJECTIVE: This is a proposal to provide two year funding for a quarterly research newsletter designed to supply information on national and international symposia, conferences, workshops, and meetings which deal with topics of interest to scientists, engineers, and students in the field of integrated ferroelectrics research. The basic research effort will be performed by a contractor. The principal investigator, Professor R. Panholzer, Space Systems Academic Group Chairman, volunteers his services and assumes the responsibility of directing the research effort at a quarterly review meeting with the research contractor.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS: Integrated Ferroelectrics

PROJECT SUMMARIES SP

SPACE SYSTEMS STUDENTS THESIS RESEARCH PROJECTS, DIRECTED STUDIES AND SPACE SYSTEMS ENGINEERING EXPERIENCE TOUR

**Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Research Laboratory**

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) students thesis research projects, directed studies, and space systems engineering experience tours.

DoD KEY TECHNOLOGY AREA: Other (Communications Networking)

KEYWORDS: Satellite Digital Communications, Direct Sequence Spread Spectrum Modulation, Over-the-Horizon Communications, Amateur Satellite, Thin-Film Ferroelectric Material

SPACE SYSTEMS STUDENTS THESIS RESEARCH PROJECTS

**Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Research Laboratory**

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) students thesis research projects, directed studies, and space systems engineering experience tours.

DoD KEY TECHNOLOGY AREA: Other (Communications Networking)

KEYWORDS: Satellite Digital Communications, Direct Sequence Spectrum Spread Modulation, Over-the-Horizon Communications, Amateur Satellite, Thin-Film Ferroelectric Material

SPACE SYSTEMS OPERATIONS EXPERIENCE TOURS

**Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Space Command**

OBJECTIVE: The objective is to provide direct interaction between the signatories to further promote and guide a focused, well-defined, and well-planned support system essential to ensure a successful, experience tour program. This program will provide valuable opportunities for practical professional development of students at NPS and will be an important investment in the Department of the Navy's strategy for space systems.

DoD KEY TECHNOLOGY AREA: Other (Space Communications)

KEYWORDS: Space Systems, Space Operations, Space Craft, Satellite Communications

NAVY TACTICAL EXPLOITATION OF NATIONAL CAPABILITIES (TENCAP) SPACE CHAIR

**Alan Ross, Navy Tactical Exploitation of National Capabilities Space Chair Professor
Space Systems Academic Group
Sponsor: Navy TENCAP Office**

OBJECTIVE: The principal objective of the TENCAP Space Chair is to provide a direct relationship between NPS, Navy TENCAP, and industry for mutual cooperation and benefit. The Chair provides a mechanism by which students can gain

PROJECT SUMMARIES SP

familiarity and exposure to existing and emerging technologies within industry and their application to Naval Space Programs and associated fleet support.

THESES DIRECTED:

Gallina, J.J., "Maritime Situational Awareness: Dedication of the On-Board Processor for a Space-Based Solution," Master's Thesis, Naval Postgraduate School, September 1998.

Jackson, D.F., "Considerations of the Tactical Real-Time Targeting System (TARTS) Support to Intelligence Operations," Master's Thesis, Naval Postgraduate School, September 1998.

Larios, M.G., "Laser Reference Beacon Concept of Operations," Master's Thesis, Naval Postgraduate School, September 1998.

Mitchell, A.K., "Multisensor Fusion and the Maritime Situational Awareness Picture," Master's Thesis, Naval Postgraduate School, September 1998.

Myers, Jeffrey S., "An Operational Utility Analysis of the Tactical Real Time Targeting System," Master's Thesis, Naval Postgraduate School, September 1998.

Wakefield, T.H., "Joint Tactical Ground Station (JTAGS) Missile Warning Dissemination Using the Global Broadcast Service (GBS)," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREA: Other (On-Board Processors, Multisensor Fusion)

KEYWORDS: Targeting, Laser Reference Beacon, GBS

NEAR-EARTH-OBJECT INTERCEPTION

I. Michael Ross, Associate Professor

Department of Aeronautics and Astronautics

Sponsor: Johns Hopkins University

OBJECTIVE: This proposal is for the purpose of analyzing certain problems associated with near-Earth-object interception. These problems need to be addressed today so that the United States and the world, at large, will be prepared to handle them when they occur tomorrow.

SUMMARY: A computer code is now available that can determine the minimum delta-V necessary to deflect an Earth-crossing asteroid (ECA). Given a warning time, the location, the direction and the magnitude of the minimum impulse necessary to safely deflect an ECA can now be determined. The results of the code yield some surprising results. The minimum point is the perihelion, but the direction is not parallel to the velocity vector as reported by other investigators. Also, when the gravitational effects of Earth are included, the delta-V is significantly higher for nearer ECAs than those that are further away. It thus appears that we may need to expend more energy to deflect an ECA than previously thought. All of these results are reported in the two papers described in the deliverables section below.

PUBLICATIONS:

Park, S.-Y. and Ross, I.M., "Two-Body Optimization for Deflecting Earth-Crossing Asteroids," *Journal of Guidance, Control and Dynamics*, to appear.

PROJECT SUMMARIES SP

Park, S.-Y. and Ross, I.M., "Gravitational Effects of Earth in Optimizing Delta-V for Deflecting Earth-Crossing Asteroids," *Proceedings of 8th AAS/AIAA Space Flight Mechanics Meeting*, AAS Paper No. 98-186, Monterey, CA, 9-11 February 1998.

DoD TECHNOLOGY AREA: Other (Space Warfare)

KEYWORDS: Space Warfare, Earth-Crossing Asteroids

MICHAEL J. SMITH SPACE SYSTEMS CHAIR PROFESSORSHIP

Lois Scaglione, Michael J. Smith Space Systems Chair Professor

Space Systems Academic Group

Sponsor: National Aeronautics and Space Administration

OBJECTIVE: The objective of the Chair Professorship is to add a faculty member dedicated to the Space Systems curricula to enhance the education of the NPS students through the teaching of courses, generation, and support of faculty and student interest in Space Systems research, and thesis advising. The incumbent also acts as a liaison between NASA and NPS on matters pertaining to teaching and research in the areas of Space Systems.

THESES DIRECTED:

Fields, D.E., "Design and Build of EVA Compatible, Bolt/Motor Bracket Assemblies for the R-SLC System and Analysis for Follow-On Reduced Gravity Testing," Master's Thesis, Naval Postgraduate School, March 1998.

Watts, M.D., "Analysis of Operational Scenarios for the Express Pallet Adapter," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Space Systems

RELOCATABLE REGIONAL SATELLITE-BASED TACTICAL MOBILE TELEPHONE NETWORK

Donald v.Z. Wadsworth, Professor

Command Control and Communications Academic Group

Craig Baldwin, Navy Space Systems Chair Professor

Space Systems Academic Group

Sponsor: Naval Space Command

OBJECTIVE: To perform the conceptual design of a DoD-owned, relocatable, regional GEO satellite-based tactical mobile telephone system, including assured-access CONOPS requirements, estimated cost and IOC dates. To consider integration with existing/planned U.S./coalition MILSATCOM, world-wide spectrum constraints, netted communications, and interoperability with commercial regional PCS. To determine feasibility of including collection against commercial regional satellite-based cellular PCS system.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Communications

PUBLICATIONS/PRESENTATIONS SP

CONFERENCE PAPERS

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile During Boost Phase," *Signal and Data Processing of Small Targets 1998*, O. Drummond, (ed.), *Proceedings of the SPIE*, Vol. 3373, pp. 528-537, 1998.

Loomis, H.H., Jr. and Betz, J., "Low Probability of Intercept Communications (U)," *MILCOM98 Classified Conference Record*, MITRE Corp., Bedford, MA, October 1998.

Park, S.-Y. and Ross, I.M., "Gravitational Effects of Earth in Optimizing Delta-V for Deflecting Earth-Crossing Asteroids," *Proceedings of 8th AAS/AIAA Space Flight Mechanics Meeting*, AAS Paper No. 98-186, Monterey, CA, 9-11 February 1998.

CONFERENCE PRESENTATIONS

Fahroo, F. and Ross, I. M., "Costate Estimation by a Legendre Pseudospectral Method," AIAA Guidance, Navigation and Control Conference, Boston, MA, 10-12 August 1998.

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile During Boost Phase," SPIE Signal and Data Processing of Small Targets Conference, Orlando, FL, April 1998.

Loomis, H.H., Jr. and Betz, J., "Low Probability of Intercept Communications (U)," MILCOM98 Classified Conference Record, MITRE Corp., Bedford, MA, October 1998.

1998 THESIS ABSTRACTS SP

ENVIRONMENTAL TESTING OF THE PETITE AMATEUR NAVY SATELLITE (PANSAT)

Paul J. Overstreet-Lieutenant Commander, United States Navy

B.S., United States Merchant Marine Academy, 1985

Master of Science in Astronautical Engineering-December 1997

Advisors: Daniel Sakoda, Space Systems Academic Group

I. Michael Ross, Department of Aeronautics and Astronautics

Any complex and expensive system requires testing to ensure adequate performance. Communications satellites require extensive testing for two additional reasons: they operate in an environment considerably different from that in which they were built and, after launch, they are inaccessible to routine maintenance and repair. The objectives of testing is not necessarily to duplicate the space environment but to approach it sufficiently so that any spacecraft that passes the tests will operate successfully in its designed space environment. The major features of the space environment that are difficult to simulate exactly are zero gravity, high vacuum, solar radiation, particle radiation and extreme temperatures. This document describes the environmental test program and the test results for the PANSAT program. PANSAT is the acronym for the Petite Amateur Navy Satellite, which is a small communications satellite under development by the Space Systems Academic Group at the Naval Postgraduate School. PANSAT subsystems were subjected to thermal vacuum and random vibration testing as part of the overall environmental test program. Satellite launch, as a Shuttle secondary payload via the Space Transportation System (STS) Small Self-contained Payload (SSCP) program, is planned for October 1998.

KEYWORDS: Environmental Testing, PANSAT, Spacecraft Testing

DoD KEY TECHNOLOGY AREA: Space Vehicles

CONVERT SUBMARINE COMMUNICATIONS USING EXTRA HIGH FREQUENCY (EHF) TRANSMISSIONS (U)

Drew J. Reiner-Lieutenant, United States Navy

B.S., United States Naval Academy, 1991

Master of Science in Systems Technology-December 1997

Advisors: Daniel Boger, Command, Control, and Communications Academic Group

Donald Wadsworth, Space Systems Academic Group

This thesis quantifies the detectability of a transmitting U.S. nuclear submarine that is using EHF communications. This is done using a communications link analysis that is performed by circular equivalent vulnerability radius (CEVR) computer algorithm that displays its results in polar graph format. CEVRs for two different communication suites under alternative scenarios are calculated. Furthermore, by performing such an analysis onboard a submarine in precarious waters, the necessary real-time information for evaluating the risk of using such EHF communication transmissions would be available instantaneously.

KEYWORDS: Submarine, EHF, Communication

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

1998 THESIS ABSTRACTS SP

THERMAL ANALYSIS OF PANSAT

Travis R. Smith-Lieutenant, United States Navy

B. S., Virginia Polytechnic Institute and State University, 1990

Master of Science in Astronautical Engineering-December 1997

Advisors: Oscar Biblarz, Department of Aeronautics and Astronautics

Ashok Gopinath, Department of Mechanical Engineering

Daniel Sakoda, Space Systems Academic Group

The thermal control system of a spacecraft is designed to maintain all spacecraft components within their specified operating temperature limits throughout all phases of a spacecraft's mission. In order to verify and aid in such a design process, a thermal analysis of the system must be conducted. A thermal model of the spacecraft is used to simulate its behavior under given thermal environments and boundary conditions so that temperature predictions can be made.

The focus of this thesis is to develop and analyze thermal models of PANSAT which describe its thermal behavior while it is in orbit and also prior to its insertion in its orbit (while it is still in the shuttle). The results of these analyses will serve to help in the thermal design and performance of PANSAT. This thesis completes the thermal model prerequisites of the STS 95 space shuttle mission hitchhiker program for PANSAT. The emphasis of this thesis is to develop a model that will allow the prediction of the temperatures of all the electrical components including the temperature sensitive electrical components of PANSAT such as batteries over a complete orbit of the satellite.

KEYWORDS: Thermal Analysis, Spacecraft Thermal Control

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Modeling and Simulation

**UNDERSEA WARFARE
ACADEMIC GROUP**

**James Eagle
Chair**

FACULTY LISTING UW

Eagle, James
Professor and Chair
UW or OR/Er
831-656-2654 (phone)
831-656-3679 (fax)
jeagle@nps.navy.mil

Baker, Steve
Associate Professor
PH/Ba
831-656-2732/2729/2824
srbaker@nps.navy.mil

Chiu, Ching-Sang
Professor
OC/Ci
831-656-3239/2160
chiu@nps.navy.mil

Muir, Tom
Chair of Mine Warfare
UW
831-656-2185/1017
tgmuir@nps.navy.mil

Bourke, Robert
Professor
OC/Bf
831-656-2673
bourke@nps.navy.mil

Hippenstiel, Ralph D.
Associate Professor
EC/Hi
831-656-2633
hippenst@nps.navy.mil

Sanders, James V.
Associate Professor
PH/Sd
831-656-3884
jsanders@nps.navy.mil

Breemer, Jan
Associate Professor
UW/Be
831-656-3486
jbreemer@nps.navy.mil

McMaster, Michael CDR
Curricular Officer
Code 37
831-656-2137
mmcmaster@nps.navy.mil

Scandrett, Clyde
Associate Professor
MA/Sd
831-656-2027
cscand@nps.navy.mil

Brutzman, Donald
Assistant professor
UW/Br
831-656-2149
Brutzman@nps.navy.mil

Miller, Christopher W.
Research Assistant
UW/
831-656-2160
cwmiller@nps.navy.mil

Smith Kevin B.
Assistant Professor
PH/Sk
831-656-2107
kbsmith@nps.navy.mil

GROUP SUMMARY UW

The Undersea Warfare Academic Group (USWAG) consists of ten faculty members plus the Curricular Officer. The faculty members teach in the USW curriculum and are responsible for its academic content. Members conduct USW-related research and serve as thesis advisors for USW students.

Associate Professor Steve Baker (Physics)
Professor Robert Bourke (Oceanography)
Associate Professor Jan Breemer (Undersea Warfare)
Assistant Professor Donald Brutzman (Undersea Warfare)
Associate Professor Ching-Sang Chiu (Oceanography)
Professor James Eagle (Operations Research), Chair
Associate Professor Ralph Hippenstiel (Electrical and Computer Engineering)
Research Assistant Christopher Miller (Undersea Warfare)
Professor Tom Muir (Undersea Warfare), Chair of Mine Warfare
Associate Professor James Sanders (Physics)
Associate Professor Clyde Scandrett (Mathematics)
Assistant Professor Kevin Smith (Physics)
CDR Mike McMaster, USW Curriculum Officer

An overview of research sponsored or co-sponsored by the USWAG is below.

CHAIR PROFESSORSHIP OF MINE WARFARE

Professor Muir continued to teach and train officers in the art and science of mine warfare, conduct mine warfare research, and helped establish NPS as an intellectual center of excellence in this arena. Professor Muir developed and taught a mine warfare course, managed a mine warfare lecture series, and conducted research with NPS students.

SEISMO ACOUSTIC DETECTION OF MINES BURIED IN THE SURF ZONE

Professors Tom Muir and Steven Baker continued their research aimed at improving the procedures for detecting buried mines using seismic waves. They developed new seismic sources which are over 1000 times more powerful than previous devices and determined the seismic target strengths of several test mine-like objects.

UNDERSEA WARFARE IN THE TWENTIETH CENTURY: STRATEGIC AND OPERATIONAL LESSONS FOR THE FUTURE

Professor Breemer conducted research with the aim of developing a new course for the Undersea Warfare Curriculum addressing Undersea Warfare in the 20th Century. The course was developed and taught during the Spring Quarter 1998. This research examined the evolution of submarine- and anti-submarine (ASW) strategy and operations in this century. A particular goal was to explore: (a) how the ASW defender has historically gone about defeating the submarine's war-making purposes at the strategic and operational levels of war and (b) whether this experience will be relevant into the next century. It was found that, despite vast changes in technical capabilities, the ASW defender's "menu" of strategic and operational choices has remained, by and large, unchanged.

HORIZON CONCEPT: ISSUES CONCERNING THREE-YEAR DEPLOYMENTS

Professor Breemer continued his study aimed at examining the operational and national policy issues which may arise when the U.S. Navy forward deploys combatants overseas for three years in lieu of the current six months. Under this concept, entitled HORIZON, crews would be rotated approximately every six months.

GROUP SUMMARY UW

SHELFBREAK PRIMER DATA ANALYSIS: ACOUSTIC PROPAGATION AND OCEAN TOMOGRAPHY

Professor Chiu continued the Shelfbreak PRIMER field study with a comprehensive data analysis of the collected data. Based on cross-shelf summer temperature sections obtained by a SeaSoar, the variability of the modal arrival structure caused by a mesoscale event was computed using a broadband, coupled normal-mode propagation model. This event corresponded to the intrusion of and later exit of a warm, saline small eddy, the remnant of a warm-core ring absorbed earlier by the Gulf Stream. Using daily cross-front winter sound-speed sections provided by the Harvard group, an initial modeling study of the variability of the winter acoustic transmissions was also conducted. An inverse tomographic analysis was performed for studying the frontal variability. In deriving the tomographic maps, an adaptive beamformer was first used to detect, resolve, and track individual acoustic ray and modal arrivals from a 224-Hz and a 400-Hz source on the slope to a vertical array on the shelf. A modal inverse technique was then applied to the resolved arrivals to produce a time series of cross-frontal images of ocean temperature. The tomographic observations were interpreted together with the SeaSoar, acoustic doppler current profiler (ADCP) and thermistor data.

MONITORING WHALES USING THE PT. SUR ACOUSTIC ARRAY - A FEASIBILITY STUDY

Professors Chiu and Collins investigated the feasibility of: (1) locating, tracking, counting and determining the transit paths of blue whales in central California water using the former Pt. Sur SOSUS hydrophone array and (2) converting the former Pt. Sur SOSUS facility into a dual-use Ocean Acoustic Observatory for the purpose of marine research.

A four-day field experiment was designed and conducted to test the feasibility of detecting, classifying, localizing, and tracking blue whales at long ranges acoustically using a former SOSUS listening array located at the Naval Postgraduate School Ocean Acoustic Observatory (OAO) at Pt. Sur, California. The experiment was a collaborative effort involving scientific investigators and graduate students from the Naval Postgraduate School, Monterey Bay Aquarium Research Institute, University of California at Santa Cruz, and NOAA's Monterey Bay National Marine Sanctuary Office. During the experiment, full-array data were archived continuously at the OAO using a newly developed 32-channel data acquisition system sampling at 2 kHz. In concert with the shore-based acoustic monitoring, an aircraft was assigned to locate blue whales in the Monterey Bay National Marine Sanctuary and to direct a research vessel to a whale site. The research vessel was manned with observers and instrumented with a towed hydrophone array to ground-truth the locations of the blue whales and classify the vocalized near-field signals. These shipboard measurements were required to provide a means to separate the source signal characteristics from the multipath signatures for the calibration and validation of broadband, model-based localization methods. Data analysis as well as computer modeling efforts in FY98 have focused on the understanding of the characteristics of the blue whale calls, the predictability of the propagation of sound in the central California coastal ocean, the uniqueness of the location-dependent multipath structure and the robustness of various matched signal algorithms, all of these are fundamental to the applicability of the concept of locating, tracking and counting blue whales using the former SOSUS array at Pt. Sur.

INTERNATIONAL WORKSHOPS IN SHALLOW-WATER ACOUSTICS

Professor Ching-Sang Chiu continued work toward the long-term goal of formulating and conducting a collaborative international experiment in the seas of China. Such an experiment will focus on studying the physics and variability of sound propagation and scattering that are unique to the coastal waters of the Asian Pacific region. The FY97 objective was to promote scientific exchange and establish a dialog between Asian and U.S. scientists who are active in shallow-water acoustics research.

Two International Workshops were organized. The Phase I Workshop was held in San Francisco on 8-9 December 1997. The Phase II Workshop was held in Seattle on 27 June 1998. Two technical reports were generated and distributed to the participants. The reports summarize the presentations, discussions, and findings of both the Phase I and Phase II Workshops, respectively.

The Phase I Workshop featured a series of short presentations by the representatives of the different countries on their research interests, and what resources they might be able to contribute to a collaborative experiment if it were to take place in 2000. A group discussion on potential sites, research vessels, surveying and moored equipment, and scientific issues was also carried out.

GROUP SUMMARY UW

The discussion of a collaborative international experiment was continued in the Phase II Workshop. The Phase II Workshop resulted in the establishment of a comprehensive list of experimental objectives and a preliminary experimental configuration.

CALIFORNIA CURRENT MONITORING USING THE NPS OCEAN ACOUSTIC OBSERVATORY

Professors Chiu and Collins continued research as part of an inter-institutional partnership project called "Ocean Acoustic Observatory Federation." The Naval Postgraduate School (NPS) component has two specific objectives: (1) the operation/maintenance of the NPS Ocean Acoustic Observatory at Pt. Sur and (2) the implementation of a real-time ocean acoustic tomography network to monitor the California Current System. On the operation/maintenance of the Pt. Sur Observatory, 1998 accomplishments include: (1) development and installation of a UNIX-based multi-channel data acquisition system at Pt. Sur; (2) continued continuous unclassified (single-phone) data collection and distribution to approved official users, and began continuous classified (full-array) data archival; (3) continued trouble-shooting the full-array data acquisition system for increased reliability; (4) certification of the secure processing facility at NPS has been completed for the NPS side of the secure T1 data link; and (5) construction work has begun for the telephone system upgrade repair. This will provide the adequate services for both analog voice lines and the T1 data line to NPS.

The implementation of the ocean-margin tomography observational network to study the California Current will involve the deployment of a Scripps' HLF-5 sound source on top of the Hoke Seamount, 600 km off shore. The signal transmissions will be monitored by (former) SOSUS receiver arrays at Pt. Sur, San Nicholas, and Barbers Point. The planning of an April cruise to deploy the source has begun. The planning involves mooring design, hardware procurement, signal transmission scheduling, CTD grid design, and addressing marine mammal compliant issues.

PROJECT SUMMARIES UW

PROPOSAL TO STUDY THE NATURE OF INFORMATION WARFARE

Jan S. Breemer, Associate Professor
Undersea Warfare Academic Group
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Explore the essential characteristics of Information Warfare (IW)

SUMMARY: A Core Study Group on Information Warfare (CSGIW), including civilian scholars from eight different academic institutions, was formed and met as a working group on three different occasions for the purpose of examining and developing a conceptual framework for guiding our thinking and understanding of IW as a form of conflict. The group produced a series of working papers as well as a final report, entitled "The Risky Game Plan: The Information Revolution and American Military Power."

PUBLICATION:

Breemer, Jan S., "The Risky Game Plan: The Information Revolution and American Military Power," *Foreign Affairs* in review.

DoD KEY TECHNOLOGY AREAS: Sensors, Human Systems Interface

KEYWORDS: Information Warfare

UNDERSEA WARFARE IN THE TWENTIETH CENTURY: STRATEGIC AND OPERATIONAL LESSONS FOR THE FUTURE

Jan S. Breemer, Associate Professor
Undersea Warfare Academic Group
Sponsor: Naval Sea Systems Command

OBJECTIVE: To conduct research with the aim of developing a graduate course addressing the evolution of undersea Warfare (USW) in the 20th century.

SUMMARY: This research examined the evolution of submarine- and anti-submarine (ASW) strategy and operations in this century. A particular goal was to explore: (a) how the ASW defender has historically gone about defeating the submarine's war-making purposes at the strategic and operational levels of war and (b) whether this experience will be relevant into the next century. It was found that, despite vast changes in technical capabilities, the ASW defender's "menu" of strategic and operational choices has remained, by and large, unchanged. The *strategic* choices are to: (a) destroy the submarine, (b) contain the submarine and its weapons, or (c) blunt the submarine's war-making efficiency. The defender's *operational* choices are to destroy, contain, or blunt the submarine's war-making efficiency at: (1) its source (e.g., bases, building yards), (2) while in transit, or (3) while in its patrol area. Technology has served mainly to periodically re-arrange this basic matrix of nine choices. A graduate level course built around study results was offered in the summer of 1998.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Submarine Warfare, Anti-submarine Warfare, Mine Warfare, Mine Countermeasures, Naval Strategy/Operations

PROJECT SUMMARIES UW

HORIZON CONCEPT: ISSUES CONCERNING THREE-YEAR DEPLOYMENTS

Jan S. Breemer, Associate Professor

Undersea Warfare Academic Group

Sponsor: Naval Air Warfare Center-Carderock Division

OBJECTIVE: This continuing study effort is aimed at examining the operational and national policy issues which may arise from the institution of a U.S. Navy forward deployment concept whereby combatants would remain on overseas stations for three years in lieu of the current six months. Under this concept, entitled HORIZON, crews would be rotated approximately every six months.

SUMMARY: The study has focused so far on the possible implications of a de-coupled ship/crew forward deployment concept for these three national security concepts: (1) international stability, (2) deterrence, and (3) warfighting. A series of working papers remain in preparation.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Forward Presence, Deterrence, Crisis Response, War-Fighting

SHELFBREAK PRIMER DATA ANALYSIS: ACOUSTIC PROPAGATION AND OCEAN TOMOGRAPHY

Ching-Sang Chiu, Professor

Department of Oceanography and Undersea Warfare Academic Group

Sponsors: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The acoustic objectives of the Shelfbreak PRIMER field study, which took place in a shelf-slope region south of New England, are: (1) to determine the effects of seasonal and mesoscale variability of the shelf-break frontal thermal structure on the transmission of sound from the slope to the shelf; (2) to relate the temporal and spatial variability of the acoustic propagation with the ocean variability in the frontal zone; and (3) to obtain tomographic maps of the frontal region for use in the characterization of the ocean variability.

SUMMARY: Based on cross-shelf summer temperature sections obtained by a SeaSoar, the variability of the modal arrival structure caused by a mesoscale event was computed using a broadband, coupled normal-mode propagation model. This event corresponded to the intrusion of and later exit of a warm, saline small eddy, the remnant of a warm-core ring absorbed earlier by the Gulf Stream. This intrusion caused significant distortion in the frontal boundary. The modeled arrival structure for the different days shows that the resultant travel-time changes are on the order of 100 ms, which is in agreement with the observed changes discussed above. The model results also show an increase of signal level during the warm intrusion. This model prediction of a warm enhancement is also consistent with the VLA observations.

Using daily cross-front winter sound-speed sections provided by the Harvard group, an initial modeling study of the variability of the winter acoustic transmissions was also conducted. These winter sound-speed fields were the output of a Harvard ocean model run with assimilated winter oceanographic data. Unique to the winter sound-speed fields is the presence of complex double ducts (i.e., an upward refracting surface duct and a downward refracting bottom duct) on the slope. The double ducts merged into a single upward-refracting channel on the shelf. Large temporal variability is found in the modeled TL and modal coefficients. The depth of the boundary separating the surface and bottom ducts on the slope as well as its range variations are found to control, to a large extent, the initial partitioning of the acoustic energy (i.e., how much energy goes into and becomes trapped in the surface duct and how much remains in the bottom duct). The range variations of this boundary also causes significant mode coupling on the slope. Therefore, the temporal variability of this boundary is likely to be responsible for the large fluctuations in the slope-to-shelf winter sound field.

An inverse tomographic analysis was performed for studying the frontal variability. In deriving the tomographic maps, an adaptive beamformer was first used to detect, resolve, and track individual acoustic ray and modal arrivals from a 224-Hz and a 400-Hz source on the slope to a vertical array on the shelf. A modal inverse technique was then applied to the

PROJECT SUMMARIES UW

resolved arrivals to produce a time series of cross-frontal images of ocean-temperature. The tomographic observations were interpreted together with the SeaSoar, acoustic doppler current profiler (ADCP) and thermistor data.

PUBLICATIONS:

Chiu, C.-S., "Realistic Simulation Studies of Acoustic Signal Coherence in the Presence of an Internal Soliton Wavepacket," *Proceedings of the IOSJWHOI/ONR Internal Solitary Wave Workshop*, Victoria, B.C., Canada, 27-29 October 1998.

The SWARM Group (Headrick, R.H., Lynch, J.F., Apel, J., Badiey, M., Chiu, C.-S., Finnette, S., Orr, M., Pasewark, B., Turgut, A., Wolf, S. Kemp, J., Newhall, A., von der Heydt, K., and Tielbuerger, D.), "Acoustic Normal Mode Fluctuation Statistics in the 1995 SWARM Internal Wave Scattering Experiment," *Journal of Acoustic Society of America*, submitted and revised, 1998.

CONFERENCE PRESENTATIONS:

Chiu, C.-S., "Realistic Simulation Studies of Acoustic Signal Coherence in the Presence of an Internal Soliton Wavepacket," the IOSIWHOI/ONR Internal Solitary Wave Workshop, Victoria, B.C., Canada, 27-29 October 1998.

Chiu C.-S., Lynch, J.F., Gawarkiewicz, G., Miller, C.W., and Sperry, B., "Tomographic Maps of the New England Shelfbreak Front," Ocean Sciences Meeting, San Diego, CA, February 1998.

THESIS DIRECTED:

Miller, C.W., "Estimating the Acoustic Modal Arrivals Using Signals Transmitted From Two Sound Sources to a Vertical Line Hydrophone Array in the 1996 Shelfbreak PRIMER Experiment," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Battlespace Environments

KEYWORDS: Littoral, Acoustics, Nowcast, Shelfbreak Fronts

MONITORING WHALES USING THE PT. SUR ACOUSTIC ARRAY - A FEASIBILITY STUDY

Ching-Sang Chiu, Professor
Department of Oceanography and
Undersea Warfare Academic Group
Curtis A. Collins, Professor
Department of Oceanography

Sponsors: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: (1) To investigate the feasibility of locating, tracking, counting, and determining the transit paths of blue whales in central California water using the former Pt. Sur SOSUS hydrophone array and (2) to convert the former Pt. Sur SOSUS facility into a dual-use Ocean Acoustic Observatory for the purpose of marine research.

SUMMARY: Detecting, classifying, localizing, and tracking vocalizing whales using receiver arrays at long ranges is a combined signal processing, underwater acoustic, bioacoustic, and physical oceanographic problem. First, knowledge of the loudness and frequency-time distribution of the different whale sounds is required for classification purposes. Equally important is the understanding of the basic structure and variability of the ocean sound channel. The ocean scrambles the vocalized signal by its multipaths as the signal propagates to a distant receiver. The ability to predict the mean and variance of the propagation is thus required to unscramble the received signal and to constrain the uncertainty.

A four-day field experiment was designed and conducted to test the feasibility of detecting, classifying, localizing, and tracking blue whales at long ranges acoustically using a former SOSUS listening array located at the Naval Postgraduate

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School Ocean Acoustic Observatory (OAO) at Pt. Sur, California. The experiment was a collaborative effort involving scientific investigators and graduate students from the Naval Postgraduate School, Monterey Bay Aquarium Research Institute, University of California at Santa Cruz and NOAA's Monterey Bay National Marine Sanctuary Office. During the experiment, full-array data were archived continuously at the OAO using a newly developed 32-channel data acquisition system sampling at 2 kHz. In concert with the shore-based acoustic monitoring, an aircraft was assigned to locate blue whales in the Monterey Bay National Marine Sanctuary and to direct a research vessel to a whale site. The research vessel was manned with observers and instrumented with a towed hydrophone array to ground-truth the locations of the blue whales and classify the vocalized near-field signals. These shipboard measurements were required to provide a means to separate the source signal characteristics from the multipath signatures for the calibration and validation of broadband, model-based localization methods. Data analysis as well as computer modeling efforts in FY98 have focused on the understanding of the characteristics of the blue whale calls, the predictability of the propagation of sound in the central California coastal ocean, the uniqueness of the location-dependent multipath structure and the robustness of various matched signal algorithms, all of these are fundamental to the applicability of the concept of locating, tracking, and counting blue whales using the former SOSUS array at Pt. Sur.

PUBLICATION:

Chiu, C.-S., Morvillez, T., and Collins, C.A., "Monitoring Temperature Variability Along the California Coast Using Acoustic Tomography," *Proceedings of the 16th International Congress on Acoustics and the 135th ASA Meeting of the Acoustical Society of America*, pp. 387-388, 1998.

CONFERENCE PRESENTATIONS:

Morvillez, T., Chiu, C.-S., Collins, C.A., "Monitoring Temperature Variability Along the California Coast Using Acoustic Tomography," 16th International Congress on Acoustics and 135th Meeting of the Acoustical Society of America, Seattle, WA, 20-26 June 1998.

Chiu, C.-S., "Using SOSUS to Track Whale Migration," International Advanced Studies Institute Symposium on Detection and Analysis of Subsurface Objects and Phenomena, Monterey, CA, 19-21 October 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Battlespace Environment, Environmental Quality

KEYWORDS: Coastal, Acoustics, Whale Monitoring, Alternate Uses

INTERNATIONAL WORKSHOPS IN SHALLOW-WATER ACOUSTICS

Ching-Sang Chiu, Associate Professor
Department of Oceanography and
Undersea Warfare Academic Group
Sponsor: Office of Naval Research

OBJECTIVE: The long-term goal is to formulate and conduct a collaborative international experiment in the seas of China. Such an experiment will focus on studying the physics and variability of sound propagation and scattering that are unique to the coastal waters of the Asian Pacific region. The FY98 objectives were: (1) to identify the outstanding research topics in shallow-water acoustics which are of common interest to all participating countries and which might form the basis for a collaborative U.S.-Asia experiment in the seas of China; (2) to assess the scientific approaches and logistic issues for such an experiment; (3) to assess the available technology to support the field effort; (4) to identify potential sites for the experimental program and investigate the environmental conditions; and (5) to recommend a plan of action that will lead to a comprehensive international experiment in 2000.

SUMMARY: The approach was to hold a series of international workshops, inviting top-notch underwater acousticians and acoustical oceanographers from seven different countries including China, Japan, Korea, Singapore, Taiwan, Russia

PROJECT SUMMARIES UW

and the USA, to jointly investigate the scientific, engineering and logistic rationales that might form the basis for a comprehensive shallow-water acoustic experiment, develop common or complementary experimental objectives, identify international resources, and formulate a plan for the coordination and execution of the experiment.

Two International Workshops were organized. The Phase I Workshop was held in San Francisco on 8-9 December 1997. The Phase II Workshop was held in Seattle on 27 June 1998. Two technical reports were generated and distributed to the participants. The reports summarize the presentations, discussions and findings of both the Phase I and Phase II Workshops, respectively.

The Phase I Workshop featured a series of short presentations by the representatives of the different countries on their research interests, and what resources they might be able to contribute to a collaborative experiment if it were to take place in 2000. A group discussion on potential sites, research vessels, surveying and moored equipment, and scientific issues was also carried out.

The discussion of a collaborative international experiment was continued in the Phase II Workshop. The Phase II Workshop resulted in the establishment of a comprehensive list of experimental objectives and a preliminary experimental configuration. The objectives include:

1. Understand sound propagation along and across multiple fronts.
2. Investigate the scattering effects of the linear and non-linear internal waves.
3. Examine the acoustic effects of a strong fresh-water plume.
4. Investigate the forward scattering properties of bottom inhomogeneities.
5. Understand the geological and acoustical signature of stratigraphy produced by river sedimentation.
6. Investigate directional reverberation in an inhomogeneous medium (ocean and bottom).
7. Investigate properties of the coastal ambient noise field.
8. Investigate higher frequency coastal acoustics ($f > 1000$ Hz).
9. Investigate horizontal array coherence, as well as vertical and temporal coherence.
10. Can we learn to model and predict these effects?

PUBLICATIONS:

Chiu, C.-S. and Denner W.W., "Report on the Office of Naval Research International Workshop on Shallow Water Acoustics, San Francisco, CA, 8-9 December 1997," Naval Postgraduate School Technical Report, NPS OC-98-002PR, March 1998.

Chiu, C.-S. and Denner, W.W., "Report on the Office of Naval Research International Phase II Workshop on Shallow Water Acoustics, Seattle, 27 June 1998," Naval Postgraduate School Technical Report, NPS OC-98-005PR, September 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Battlespace Environment

KEYWORDS: Shallow-Water Acoustics

CALIFORNIA CURRENT MONITORING USING THE NPS OCEAN ACOUSTIC OBSERVATORY

Ching-Sang Chiu, Professor

Department of Oceanography and Undersea Warfare Academic Group

Curtis A. Collins, Professor

Department of Oceanography

Sponsor: Office of Naval Research and the National Science Foundation

OBJECTIVES: This is part of an inter-institutional partnership project called "Ocean Acoustic Observatory Federation." The Naval Postgraduate School (NPS) component has two specific objectives: (1) the operation/maintenance of the NPS Ocean Acoustic Observatory at Pt. and (2) the implementation of a real-time ocean acoustic tomography network to monitor the California Current System.

PROJECT SUMMARIES UW

SUMMARY: On the operation/maintenance of the Pt. Sur Observatory, our accomplishments to date include: (1) Developed and installed a UNIX-based multi-channel data acquisition system at Pt. Sur; (2) continued continuous unclassified (single-phone) data collection and distribution to approved official users, and began continuous classified (tull-array) data archival; (3) continued trouble-shooting the full-array data acquisition system for increased reliability; (4) certification of the secure processing facility at NPS has been completed for the NPS side of the secure T 1 data link; and (5) construction work has begun for the telephone system upgrade repair. This will provide the adequate services for both analog voice lines and the T 1 data line to NPS.

The implementation of the ocean-margin tomography observational network to study the California Current will involve the deployment of a Scripps' HLF-5 sound source on top of the Hoke Seamount, 600 km off shore. The signal transmissions will be monitored by (former) SOSUS receiver arrays at Pt. Sur, San Nicholas, and Barbers Point. The planning of an April cruise to deploy the source has begun. The planning involves mooring design, hardware procurement, signal transmission scheduling, CTD grid design, and addressing marine mammal compliant issues.

CONFERENCE PRESENTATION:

Chiu, C.-S., "The NPS Ocean Acoustic Observatory and Coastal Tomography," First Meeting of the Ocean Acoustic Observatory Federation, La Jolla, CA, 9-10 September 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Battlespace Environment

KEYWORDS: SOSUS, Alternate Uses, Coastal Tomography, California Current

CHAIR PROFESSORSHIP OF MINE WARFARE

Thomas Muir, Chair of Mine Warfare

Undersea Warfare Academic Group and

Department of Physics

James Eagle, Undersea Warfare Academic Group and

Department of Operations Research

Sponsors: Chief of Naval Operations (N85) and

Naval Sea Systems Command

OBJECTIVE: To teach and train officers of the naval and military services in the arts and sciences of mine warfare; and to conduct research, and bring national and international attention to this subject at the Naval Postgraduate School, thereby developing an intellectual center of excellence in this arena.

SUMMARY: A course on mine warfare was taught in the Department of Physics to students of undersea warfare and combat systems. A distinguished lecture series, featuring outside experts, was conducted by the chair professor, and involved video teleconferencing lectures from the Navy's mine warfare, center of excellence, the Coastal Systems Station, Panama City FL. Experimental research at sea, was conducted by the chair and his students and colleagues on dolphin sonar, at the Navy's marine mammal center of excellence, the Space and Warfare Systems Research Center, San Diego CA. The chair's main research activities were done on the Navy beach in Monterey, CA, on seismic sonar for the detection of buried mines, in the surf zone. Some five of the very best NPS thesis students studied with the chair professor, and his colleagues, and they became honor graduates: some with multiple (per student) Master of Science Degrees in Physics, Acoustical Engineering, and Mechanical Engineering. Most all of these degrees were earned with some of the highest NPS academic honors, such as *With Distinction*, or other highest awards, such as the *Chief of Naval Operations Award for Excellence in Undersea Warfare*, the *Naval Sea Systems Command Award for Excellence in Combat Systems*, the *Naval Postgraduate School Outstanding Thesis Award*, the *Naval Postgraduate School Superior Service Award*, and the *Marine Corps Association Superior Service Award for the Outstanding U.S. Marine Student*. Two of the chair's students were awarded the *U.S. Military Outstanding Volunteer Service Medal*, for service to the community, while studying with the chair and his colleagues, during their tour of duty at NPS.

PROJECT SUMMARIES UW

PUBLICATION:

Smith, Eric, Wilson, Preston, Bacon, Fred, Manning, Jason, Behrens, John, and Muir, Thomas, "Measurement and Localization of Interface Wave Reflections From a Buried Target," *Journal of the Acoustical Society of America*, Vol. 103, No. 5, Pt. 1, pp. 2333-2343, May 1998.

CONFERENCE PRESENTATION:

Muir, T., "Mine Warfare and the Activities of the Chair Professor at the Naval Postgraduate School," North Atlantic Treaty Organization Meeting on Mine Warfare (NGI3 Group, and Sub-Groups), Monterey, CA, 30 March-3 April 1998.

THESES DIRECTED:

Gagan, F. Jr., "Discrete-Mode Source Development and Testing for New Seismo-Acoustic Sonar," Master's Thesis, Naval Postgraduate School, March 1998.

Toland, R., "High Frequency Components in the Sonar Transmissions of Dolphins," Master's Thesis, Naval Postgraduate School, September 1998.

Fitzpatrick, S., "Development of a Seismo-Acoustic Sonar," Master's Thesis, Naval Postgraduate School, December 1998.

Hall, P., "Seismic Target Strength of Buried Ordnance," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Conventional Weapons, Electronics, Sensors, Other (Mine Warfare)

KEYWORDS: Mining, Mine Countermeasures, Surf Zone, Seismic Sonar, Biosonar

SEISMO ACOUSTIC DETECTION OF MINES BURIED IN THE SURF ZONE

Thomas Muir, Chair of Mine Warfare
Undersea Warfare Academic Group and
Department of Physics
Steven Baker, Associate Professor
William Maier, Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To determine the seismic target strengths (reflectivity) of test targets and inertly loaded naval/military mines that are buried in surf zone sediments.

SUMMARY: New seismic sources were developed, over a thousand times more powerful than previous devices. These new sources were used to measure the target strengths of mine-like objects buried in wet sand on the Navy beach fronting Monterey Bay. Two test targets were used: a long cylinder (helium tank) and a squat cylinder (a powder keg). The results of the measurements are documented in the theses cited below.

PUBLICATION:

Smith, Eric, Wilson, Preston, Bacon, Fred, Manning, Jason, Behrens, John, and Muir, Thomas, "Measurement and Localization of Interface Wave Reflections From a Buried Target," *Journal of the Acoustical Society of America*, Vol. 103, No. 5, Pt. 1, pp. 2333-2343, May 1998.

PROJECT SUMMARIES UW

CONFERENCE PRESENTATION:

Muir, T., "Mine Warfare and the Activities of the Chair Professor at the Naval Postgraduate School," North Atlantic Treaty Organization Meeting on Mine Warfare (NGI3 Group, and Sub-Groups), Monterey, CA, 30 March-3 April 1998.

THESES DIRECTED:

Fitzpatrick, S., "Development of a Seismo-Acoustic Sonar," Master's Thesis, Naval Postgraduate School, December 1998.

Hall, P., "Seismic Target Strength of Buried Ordnance," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Conventional Weapons, Electronics, Sensors, Mine Warfare

KEYWORDS: Mining, Mine Countermeasures, Surf Zone, Seismic Sonar, Biosonar

PHYSICS OF SEISMIC INTERFACE WAVES IN THE SURF ZONE

Thomas Muir, Chair of Mine Warfare
Undersea Warfare Academic Group and

Department of Physics
Steven Baker, Associate Professor

William Maier, Professor
Department of Physics

Sponsor: Office of Naval Research

OBJECTIVE: To experimentally test the hypothesis that seismic interface waves (such as Rayleigh waves) can be discretely excited and can be reflected off buried objects, producing detectable echoes.

SUMMARY: Discrete Rayleigh wave excitation was not achieved in the vicinity of the experimental sources. However, it was found that the medium itself acted as a selective filter for Rayleigh interface waves, after a few tens of meters of propagation. It was determined that a seismic sonar for buried ordnance detection at a few meters range might be subject to the confusing effects of multi wave-type interference and reverberation, while one operating at a few tens of meters range might be immune from these difficulties. This pointed to the direction of sources with higher source levels, which are required for longer-range propagation.

PUBLICATION:

Smith, Eric, Wilson, Preston, Bacon, Fred, Manning, Jason, Behrens, John, and Muir, Thomas, "Measurement and Localization of Interface Wave Reflections From a Buried Target," *Journal of the Acoustical Society of America*, Vol. 103, No. 5, Pt. 1, pp. 2333-2343, May 1998.

CONFERENCE PRESENTATION:

Muir, T., "Mine Warfare at the Naval Postgraduate School," North Atlantic Treaty Organization Meeting on Mine Warfare (NG/3 Group, and Sub-Groups) Monterey, CA, 30 March-3 April 1998.

THESIS DIRECTED:

Gagan, F. Jr., "Discrete-Mode Source Development and Testing for New Seismo-Acoustic Sonar," Master's Thesis, Naval Postgraduate School, March 1998.

PROJECT SUMMARIES UW

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Conventional Weapons, Electronics, Sensors, Mine Warfare

KEYWORDS: Mining, Mine Countermeasures, Surf Zone, Seismic Sonar

PUBLICATIONS/PRESENTATIONS UW

JOURNAL PAPER

Smith, Eric, Wilson, Preston, Bacon, Fred, Manning, Jason, Behrens, John, and Muir, Thomas, "Measurement and Localization of Interface Wave Reflections From a Buried Target," *Journal of the Acoustical Society of America*, Vol. 103, No. 5, Pt. 1, pp. 2333-2343, May 1998.

CONFERENCE PAPERS

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1998 THESIS ABSTRACTS UW

REAL-TIME MODELING OF CROSS-BODY FLOW FOR TORPEDO TUBE RECOVERY OF THE *PHOENIX* AUTONOMOUS UNDERWATER VEHICLE (AUV)

Kevin Michael Byrne-Lieutenant, United States Navy

B.S., State University of New York Maritime College, 1991

Master of Science in Computer Science-March 1998

Advisor: Don Brutzman, Undersea Warfare Academic Group

Second Reader: Robert P. McGhee, Department of Computer Science

A virtual world provides an exceptional resource for the testing and development of an Autonomous Underwater Vehicle (AUV). The difficulties associated with the underwater environment are numerous and complex. In order to properly verify vehicle results in the laboratory such a world must accurately model the physics associated with the vehicle, its submerged hydrodynamics characteristics, and interactions with the environment. Environmental effects such as wave motion, currents, and flow forces created by bodies moving through the water can cause unpredicted performance variations and failures in the ocean environment. The current *Phoenix* AUV virtual world includes steady-state ocean currents, but does not take into account the environmental effects of waves and flow forces induced by adjacent vehicles (such as a moving submarine docking target).

This work provides a thorough real-time simulation of these complex factors using physically-based models. The problem is broken down into wave motion effects, submarine-induced flow fields, and virtual sensors to improve AUV motion control. Each set of forces is thoroughly analyzed and realistically simulated in real-time through the algorithms developed. In order to maintain real-time response, perturbations in the flow field caused by the AUV itself are assumed to be negligible. Simulated testing is performed across a range of easy to worst-case scenarios in order to justify assumptions. Extensive testing using virtual sensors is used to develop adequate control algorithms in the presence of turbulent cross-body flow.

The result of this research is an enhanced virtual world which more accurately depicts the ocean environment, along with the models and control algorithms required to design and operate an AUV during submarine launch and recovery. A platform independent approach to virtual environment simulation is presented through the use of the Virtual Reality Modeling Language (VRML) and Java. Finally, simulation test results provide strong evidence that AUV control with actual cross-body flow sensors can enable stable navigation, first through a turbulent flow field and then for subsequent docking with a moving submarine.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Virtual Environment, Simulation-Based Design, Cross-Body Flow, Autonomous Underwater Vehicle (AUV), Platform-Independent Simulation

COORDINATED INLAND AREA SEARCH AND RESCUE (SAR) PLANNING AND EXECUTION TOOL

Timothy S. Castle-Lieutenant, United States Coast Guard

B.S., United States Coast Guard Academy, 1991

Master of Science in Operations Research-September 1998

Advisors: Gordon Bradley, Department of Operations Research

Alan Washburn, Department of Operations Research

Second Reader: James Eagle, Undersea Warfare Academic Group

This thesis designs and implements the Coordinated Inland Area Search and Rescue (SAR) System (COINSS). This system provides several important features not provided by current inland SAR computer systems. First is the ability to model movement of the target. Second is modeling the effect terrain has on the movement of the target. Third is the visual presentation of a probability map, a color display showing the probability that the target is located at various geographic positions. COINSS is developed in the Java programming language. It is designed to be implemented with a map-based planning system using loosely coupled components. COINSS provides the initialization, movement, and search algorithms

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which are used by the planning system to support the search operation. The initialization algorithms define the search area where the SAR operation will occur. Initial areas are defined for the target. COINSS models the movement of the target as a discrete time Markov chain. Bayes theorem is used to update the probability map when negative search information is provided. This thesis will improve inland SAR operations by providing the first model with an interactive graphical user interface and a model of target movement.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Search and Rescue, Java, Loosely Coupled Components, Map Based Planning

SUBMARINE PERISCOPE DEPTH COURSE SELECTION TACTICAL DECISION AID

D.J. Danko-Lieutenant, United States Navy

B.S.E., University of Washington, 1990

Master of Science in Operations Research-December 1997

Advisor: Alan R. Washburn, Department of Operations Research

Second Reader: James N. Eagle, Undersea Warfare Academic Group

Coming to periscope depth is one of the most intensive of the routine submarine operations. Errors in fire control and sonar system information serve to produce uncertain contact solutions that complicate the decision of selecting a safe course. The model developed in this thesis simulates a specified number of trials on each possible course, with the measure of effectiveness for each course being the probability of the course being acceptable with respect to specified minimum range criteria. The model outputs a geographic display and a graph of the measures of effectiveness versus course.

KEYWORDS: Submarine Periscope Depth Operations, Course Selection, Tactical Decision Aid, Simulations Using Visual Basic Programming

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles-Ships and Watercraft Ground Vehicles

TESTING AND DEVELOPMENT OF A LOW COST, DIGITAL SIGNAL PROCESSOR-(DSP) BASED TORPEDO COUNTERMEASURE (U)

Mark T. Evans-Lieutenant, United States Navy

B.S., United States Naval Academy, 1992

Master of Science in Engineering Acoustics-September 1998

and

Robert J. Jezek Jr.-Lieutenant, United States Navy

B.S., United States Naval Academy, 1992

Master of Science in Engineering Acoustics-September 1998

Advisors: Donald P. Brutzman, Undersea Warfare Academic Group

Thomas G. Muir, Chair of Mine Warfare

The wide spread proliferation of modern submarines and torpedoes has significantly increased the threat to U.S. Naval Forces. Current U.S. torpedo countermeasures are not as effective against the latest generation of torpedoes. A new torpedo countermeasure is required to provide an acceptable defense against these new weapons.

The cost of any system is an important characteristic in today's restrictive fiscal policy. The use of Commercial-off-the-shelf (COTS) technology can significantly reduce development and procurement costs of any military program.

This thesis details the acoustic testing, troubleshooting, and development of a new type torpedo countermeasure. This torpedo countermeasure is based on a Digital Signal Processor that allows a computer microprocessor to analyze a torpedo's sonar signal and generate an appropriate response signal as dictated by its programming. This gives flexibility that is a significant improvement over today's dedicated hardware systems and enables the device to outperform current countermeasures. Extensive use of COTS technology has minimized the cost of a prototype device. Computer simulation has

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played a large role in troubleshooting countermeasure software. Laboratory acoustic testing of the prototype hardware and software is described in detail, along with the resulting problems, proposed solutions and additional developmental steps.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Conventional Weapons

KEYWORDS: Torpedo Countermeasures, Digital Signal Processing, Acoustic Modem, Acoustic Telemetry, Acoustic Decoy, Signal Analysis

SURFACE SHIP SENSOR EMPLOYMENT AGAINST DIESEL SUBMARINES

Matthew Jordan Harrison-Lieutenant, United States Navy

B.S., United States Naval Academy, 1992

Master of Science in Operations Research-March 1998

Advisors: Wayne P. Hughes, Department of Operations Research

Don Brutzman, Undersea Warfare Academic Group

Second Reader: RADM John J. Ekelund Jr., USN (Ret)

This thesis provides tactical guidance for employment of surface ship sensors against torpedo-armed diesel submarines during littoral operations. Advantageous utilization of antisubmarine sensor systems in the littoral environment incorporates a blend of competent tactical experience and innovative thought processes and reflects environmental conditions, threat status, and mission priorities. Through extensive use of a modeling and simulation program, this thesis determines the preferred sensor employment configurations based on surface ship and submarine detection and counter-detection ranges and vulnerabilities to torpedo attack. Preference is based on a measure of effectiveness that minimizes the risk faced by surface ships from a diesel submarine threat, and provides tactical recommendations that are readily implementable as sensor employment policies.

DoD KEY TECHNOLOGY AREA: Electronic Warfare, Sensors, Surface/Under Surface Vehicles – Ships and Watercraft, Modeling and Simulation

KEYWORDS: Antisubmarine Tactics, Simulation, Sensor Employment, Antisubmarine Warfare

REAL-TIME 3D SONAR MODELING AND VISUALIZATION

Timothy M. Holliday-Lieutenant, United States Navy

B.S., University of New Mexico, 1990

Master of Science in Applied Physics-June 1998

Advisors: Kevin B. Smith, Department of Physics

Don Brutzman, Undersea Warfare Academic Group

Virtual world simulations are realistic when each individual component is simulated in a manner that reflects reality. For an underwater virtual world that simulates acoustic detection, a physically based sonar propagation model is required if ranges in excess of tens of meters are expected.

This thesis creates an application programming interface (API) for realtime 3D computation and visualization of acoustic energy propagation. The API provides features for generating complex physically based sonar information at interaction rates, and then visualizing that acoustic information. The simulation is programmed in Java and runs either as a stand-alone program or as a script in a web browser. This program generates Virtual Reality Modeling Language (VRML 97) compliant code that can be viewed from any VRML-capable browser. This approach allows the characteristics of the energy propagation to be calculated with high precision and observed in 3D.

As sonar system information bandwidth becomes larger, more intuitive ways of presenting information to a user will be required. Higher information density in a more intuitive format can free the user from integrating the data himself and allow quicker reaction times. This thesis and the API provide the foundation for fundamental advances in sonar modeling and visualization.

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DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Modeling, Simulation, Sonar, Ray Tracing, Visualization, VRML

VRML TERRAIN MODELING FOR THE MONTEREY BAY NATIONAL MARINE SANCTUARY (MBNMS)

R. Greg Leaver-Lieutenant, United States Navy

B.S., Oklahoma State University, 1987

Master of Science in Information Technology Management-September 1998

Advisor: Don Brutzman, Undersea Warfare Academic Group

Rex Buddenberg, Information Systems Academic Group

This thesis develops an online model of the topographic terrain of Monterey Bay National Marine Sanctuary (MBNMS) seafloor. Written in the Virtual Reality Modeling Language (VRML), the model is an interactive 3D application composed of hundreds of topographic tiles linked together to form a mosaic of the bay. Low-resolution tiles are traded for higher resolution tiles as the viewer gets closer to the terrain.

Important contributions include a naming convention for autogeneration of interlinked files, test usage of proposed metadata conventions linking VRML and the eXtensible Markup Language (XML), demonstrated use of the GeoVRML Working Groups proposed QuadLOD node, and a preliminary 3D navigation icon for terrain interrogation and wayfinding. Terrain data was produced from registered, smoothed and subsampled bathymetric sonarscan results. Because the model is geo-referenced with the Universal Transverse Mercator (UTM) coordinate system, a user can easily add scientific content or data to a selected location of the MBNMS in a manner analogous to adding 2D content to an HTML page. Thus, the user can place 3D content anywhere in the MBNMS in geographic context merely by specifying the geographic coordinates and depth of the content in standard VRML syntax.

Future work includes improvement of metadata interoperability, navigation icon user testing, and autogeneration of image-based texture tiles for scientific visualization.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Environmental Quality, Human Systems Interface, Sensors, Modeling and Simulation

KEYWORDS: World Wide Web, Virtual Reality Modeling Language (VRML), Large-Scale Virtual Environments (LSVEs), Monterey Bay, 3D Graphics Modeling

SIMULATION OF THE AUTONOMOUS COMBAT SYSTEMS ROBOT OPTICAL DETECTION SYSTEM

William B. McNeal-Lieutenant, United States Navy

B.S., Southern University, 1991

M.P.A, Troy State University, 1995

Master of Science in Applied Physics-December 1997

Advisors: Gordon E. Schacher, Department of Physics

Donald Brutzman, Undersea Warfare Academic Group

NPS Combat Systems students learn systems engineering through a series of courses in design, development, implementation, and testing and evaluation. In the last of this series of courses, students design an autonomous robot capable of searching, acquiring, and tracking another autonomous robot having similar capabilities. The project culminates in the Robot Wars Competition, where groups of students have their robots battle each other.

This thesis is the second in a series designed to realistically simulate the robot wars battles. The end-to-end functionality of the optical detection system is modeled, and the necessary physics are implemented for effective simulation and depiction. The model uses a transfer function approach and includes all physical processes, from initial optical beacon emission

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to final digital control signal. Exercising the model over time using realistic robot inputs yields a simulation that closely replicates real behavior. A Virtual Reality Modeling Language (VRML) program uses data files of each Simbot's movement to generate a 3-dimensional animated scene of the detection sequence. This implemented optical model effectively simulates the SE 3015 robot optical detection system and can reproduce an actual detection and tracking sequence between two robots.

KEYWORDS: Optics, Models, Simulation, Robots

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Modeling and Simulation

REMOTE NETWORK ADMINISTRATION OF THE SEANET COMMUNICATION NODE SYSTEM

Don C. Murray-Lieutenant, United States Navy

B.S., University of Oklahoma, 1991

**Master of Science in Information Technology Management-September 1998
and**

Christopher L. Pratt-Lieutenant, United States Navy

B.S., Virginia Military Institute, 1990

Master of Science in Information Technology Management-September 1998

Advisor: Rex Buddenberg, Information Systems Academic Group

Second Reader: Don Brutzman, Undersea Warfare Academic Group

Maritime data communications are expensive and of limited capacity. Currently there is no established infrastructure to support Internet connectivity for sea-going vessels. The SeaNet program is investigating maritime networking solutions. One aspect of the SeaNet program is promoting remote network management. Remote network management will provide the maritime research community with a flexible and cost-effective tool for monitoring sea based assets. The objective of this thesis is to investigate remote network management over a satellite connection in support of the SeaNet programs goals.

To research the potential for remote network management, the Naval Postgraduate School has developed its own SeaNet laboratory. This laboratory simulates both the shipboard and shore-based infrastructure of the SeaNet program and conducts remote network management on these components. This thesis discusses the SeaNet program, network management concepts, the NPS SeaNet laboratory, research findings, and recommendations for future research. Remote Network Management of the SeaNet Control Node system is possible, however, continued research in this area is needed.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Network Management, Internet-to-Sea, SeaNet

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COMPARISON OF THE UNDERWATER AMBIENT NOISE MEASURED IN THREE LARGE EXHIBITS AT THE MONTEREY BAY AQUARIUM AND IN THE INNER MONTEREY BAY

Daniel Matthew O'Neal-Lieutenant, United States Navy

B.A., The Citadel, 1992

Master of Science in Applied Physics-June 1998

Advisor: Steven R. Baker, Department of Physics

Second Reader: Thomas G. Muir, Chair of Mine Warfare

Ambient underwater acoustic noise recordings were made in three large exhibits at the Monterey Bay Aquarium and the inner Monterey Bay, with the results reported here. Observed broadband (0-6.4 kHz) acoustic noise levels ranged from 112-125 dB re 1 μ P for the aquarium exhibits under normal operating conditions. Broadband acoustic noise levels of 113 dB and 116 dB re 1 μ Pa were observed for the nearshore and offshore bay locations, respectively.

A comparison of the noise spectrum in the aquarium's largest exhibit to that of the environment which it attempts to simulate, the offshore bay, revealed a higher noise level of approximately 15-25 dB in the exhibit for frequencies between 20 Hz and 6.4 kHz. A similar comparison of the noise spectra of the two smaller exhibits and the nearshore bay location revealed a difference of approximately 5-10 dB across the entire frequency range of 0-6.4 kHz.

Aquarium measurements with various mechanical equipment (motors, fans, pumps, sprinklers, wave machine) turned on and off highlighted some of the prominent ambient noise contributors. It was concluded that the pump machinery is the greatest contributor to ambient noise, with the strength directly related to the exhibits' proximity to the machinery room.

DoD KEY TECHNOLOGY AREA: Other (Underwater Acoustic Ambient Noise)

KEYWORDS: Ambient Noise, Noise Measurements, Aquarium, Monterey Bay

AUDITORY-VISUAL CROSS-MODAL PERCEPTION PHENOMENA

Russell L. Storms-Major, United States Army

B.S., United States Military Academy, 1986

M.S., Naval Postgraduate School, 1995

Doctor of Philosophy in Computer Science-September 1998

Advisor: Michael J. Zyda, Department of Computer Science

Committee: Robert B. McGhee, Department of Computer Science

Rudolph P. Darken, Department of Computer Science

Donald P. Brutzman, Undersea Warfare Academic Group

Lawrence J. Ziomek, Department of Electrical and Computer Engineering

Durand R. Begault, NASA Ames Research Center

Elizabeth M. Wenzel, NASA Ames Research Center

The quality of realism in virtual environments is typically considered to be a function of visual and audio fidelity mutually exclusive of each other. However, the virtual environment participant, being human, is multi-modal by nature. Therefore, in order to more accurately validate the levels of auditory and visual fidelity required in a virtual environment, a better understanding is needed of the intersensory or cross-modal effects between the auditory and visual sense modalities.

To identify whether any pertinent auditory-visual cross-modal perception phenomena exist, 108 subjects participated in three main experiments which were completely automated using HTML, Java, and JavaScript computer programming languages. Visual and auditory display quality perception were measured intramodally and intermodally by manipulating visual display pixel resolution and Gaussian white noise level and by manipulating auditory display sampling frequency and Gaussian white noise level.

Statistically significant results indicate that 1) medium or high-quality auditory displays coupled with high-quality visual displays increase the quality perception of the visual displays relative to the evaluation of the visual display alone, and 2) low-quality auditory displays coupled with high-quality visual displays decrease the quality perception of the auditory displays relative to the evaluation of the auditory display alone. These findings strongly suggest that the quality of realism in virtual environments must be a function of both auditory and visual display fidelities inclusive of each other.

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DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Modeling and Simulation

KEYWORDS: Virtual Environment, Auditory Display, Visual Display, Perception, Cross Modal, Fidelity, Experimental Design

***PHOENIX* AUTONOMOUS UNDERWATER VEHICLE (AUV): NETWORKED CONTROL OF MULTIPLE ANALOG AND DIGITAL DEVICES USING LONTALK**

Forrest C. Young-Lieutenant, United States Navy

B.S., University of California at Berkeley, 1990

Master of Science in Electrical Engineering-December 1997

Advisors: Xiaoping Yun, Department of Electrical and Computer Engineering

Donald Brutzman, Undersea Warfare Academic Group

The purpose of this thesis is to simplify analog and digital device control inside the *Phoenix* autonomous underwater vehicle (AUV). *Phoenix* is required to process many data information streams associated with a variety of different sensors. Real-time processing is required both for input sensing and for output directing. As presently configured, hardware devices aboard the *Phoenix* are manually connected and configured using parallel ports, serial ports, analog-to-digital (A/D) and digital-to-analog (D/A) controller hardware. Current hardware control within *Phoenix* connects all devices individually to a single computer. This approach is cumbersome, error-prone and does not scale.

This project investigates the feasibility of using Echelon LonWorks hardware and LonTalk protocol as a faster and scalable networked robot control system. LonWorks/LonTalk is a flexible A/D D/A hardware networking technology that provides reliable communication, decentralized topology with no single point of failure, easy extensibility, excellent throughput, and interoperability for a wide variety of hardware.

This project builds and tests a prototype LonTalk network that connects all *Phoenix* devices. This network demonstrates the capability of using LonWorks to control various types of hardware and support rapid component integration onboard the *Phoenix*. Successful demonstration of a LonTalk solution eliminates a critical barrier to *Phoenix* progress and makes robot execution much more robust.

KEYWORDS: Autonomous Underwater Vehicle, AUV, Networked Control, LonWorks Technology, LonTalk, LonBuilder

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles-Ships and Watercraf

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